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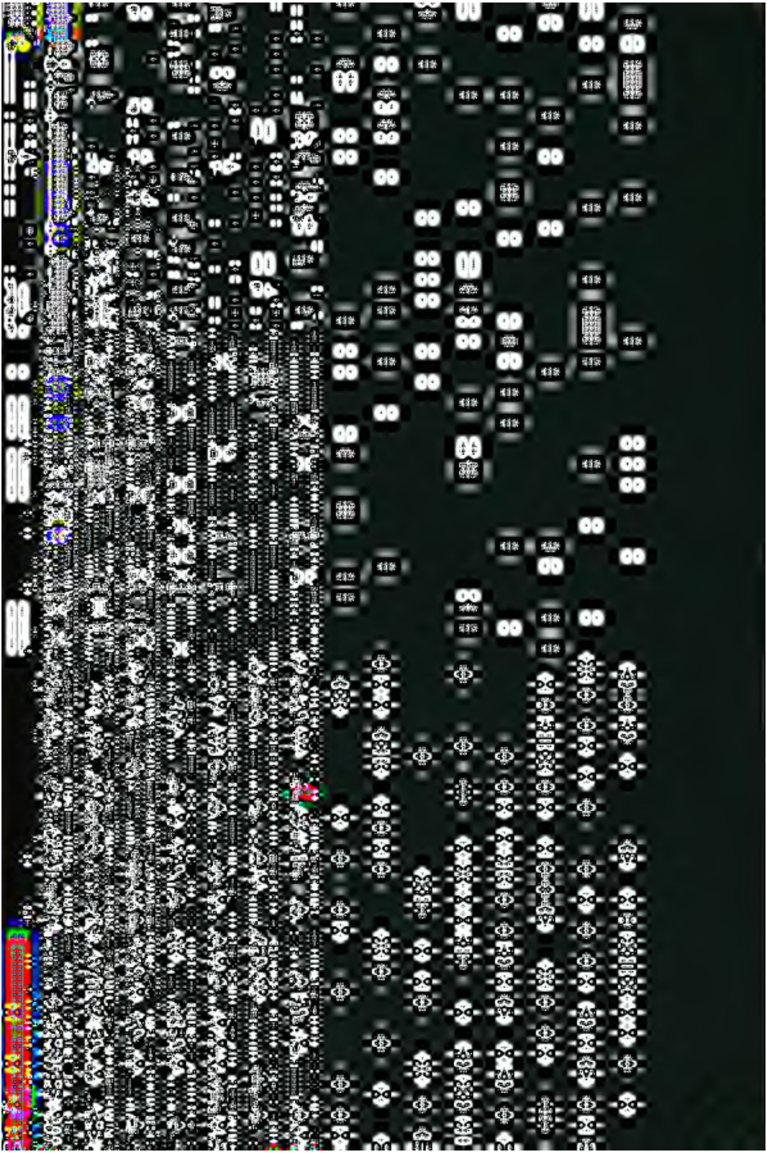

A
GENERAL VIEW
OF THE
SCIENCES AND ARTS.

VOL. II.

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A

GENERAL VIEW

OF THE

SCIENCES AND ARTS:

EQUALLY ADAPTED TO

DOMESTIC AND TO SCHOOL EDUCATION.

By W. JILLARD HORT,

AUTHOR OF "THE NEW PANTHEON," &c.

IN TWO VOLUMES.

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ERRATA.

Page 52. line 3. *for* Ishibosheth *read* Ishbosheth.
85. line 24. *for* transcendantly *read* transcendently.
118. line 22. *delete* is.
122. lines 22, 23, *for* sate *read* sat.
123. line 9. *for* them *read* him.
128. last line, *for* Madala *read* Magdala.
131. line 4. *for* towns *read* town.
169. line 29. *for* Tiberius *read* Tiberias.

A

GENERAL VIEW

OF THE

SCIENCES AND ARTS.

CHAPTER I.

OPTICS.

LIGHT. — REFRACTION.

Optics, derived from the Greek verb, signifying to see, is the term given to that science which considers the nature, the composition, and the motion of light; the changes which it undergoes from the action of bodies; the phenomena of vision, and the instruments in which light is the chief agent. This science is generally arranged in three divisions; namely, Dioptrics, which treats of the laws of refraction, and the phenomena depending upon them: Catoptrics, which treats of the laws of reflection, and the phenomena connected with them; and Chromatics, which treats of the phenomena of colour.

With regard to the nature of light, two opinions divide the philosophic world.

First, that light is produced by the undulations of an elastic fluid; nearly in the same manner as sound is produced by the undulations of the air.

Secondly, that the phenomena of vision are produced by the motion, and action, of matter emitted from the shining body, with inconceivable velocity, moving uniformly in straight lines, and acted upon by other bodies, so as to be reflected, refracted, or inflicted, in various ways. The latter was the opinion of Newton, and is now the most generally prevalent.

Every visible body emits, or reflects, inconceivably small particles of matter from each point of its surface, in straight lines, and in all directions. These particles, entering the eye, and striking upon the retina (the name given to an expansion of the optic nerve over the back part of the eye) excite in the mind the idea of light. According as these particles differ in substance, density, velocity, or magnitude, they excite the ideas of different colours; but it is the opinion of many that colours are produced by different modes of reflection and refraction.

That the particles of light are small, beyond human comprehension, appears from this: that if a hole be made in any substance, not larger than the point of a pin or needle, rays of light from every object on the other side are capable of being transmitted through it, at the same time, without any confusion; for any one of those objects may be seen through the perforation, as clearly as if no rays passed through it from any of the rest. A lighted candle, if no obstacle obstruct the progress of its rays, will fill all the space within some miles of it, every way, with luminous particles, before it has lost the least sensible part of its substance.

These particles proceed from every point of the surface of a visible body, and in all directions. This is evident, since in whatever situation the spectator is, with respect to the body, every point of that surface of it which is turned towards him, is visible.

They move in right lines. This is plain, because just so many and no more are intercepted in their passage by any interposing object, as that object would necessarily intercept, supposing them to move in right lines.

The velocity with which the particles of light move is, in the highest degree, astonishing. Their velocity is estimated by observations made on the eclipses of the satellites of Jupiter, for those eclipses are seen about seven minutes sooner than they ought to be by calculation, when the earth is placed between the sun and that planet; that is, when we are nearest to him; and seven minutes later than calculation gives, when the sun is between Jupiter and us; that is, when we are farthest from him. Hence it is concluded that the particles of light, in seven minutes, pass through a space equal to the distance of the earth from the sun.

A stream of particles of light issuing from the surface of a visible body in one and the same direction, is called a ray of light.

When light passes obliquely from one medium to another, it always quits the direction in which it was moving, and assumes a new direction. This change of course in light is called refraction.

A ray of light passing out of a thinner into a thicker medium, is refracted towards the perpendicular. That is, supposing a line drawn perpendicularly to the surface of the medium through the point where the ray enters, and extended both ways, the ray in passing through the surface is refracted, or bent towards the perpendicular line.

When a ray passes out of a thicker into a thinner medium, obliquely, it is refracted from the perpendicular.

The line which a ray describes before it enters a denser or a rarer medium, is called the incident ray, and that which it describes after having made a change of medium, is called the refracted ray.

The angle comprehended between the incident ray and the perpendicular, is the angle of incidence; and the angle which is comprehended between the refracted ray and the perpendicular, is the angle of refraction.

Refraction diminishes as the incident velocity increases.

The rainbow; the apparent deviation of the celestial objects from their true situations; the action of telescopes and microscopes, that are constructed with glass lenses; the camera obscura; spectacles, and the effects of lenses in general; all depend upon the refraction of light.

If, instead of falling obliquely upon any medium, the rays of light fall perpendicularly upon it; or if they continue in the same medium, then they proceed in straight lines, without any perceptible deviation.

The refraction of light is illustrated by many experiments.

Take a glass vessel; lay a card, having a small hole in its middle, upon the aperture of the vessel, and fix a lamp or candle above it, so as that the flame may stand perpendicularly over the hole in the card; which may be done by means of a plummet. Then the image of the hole will be cast upon the bottom of the glass vessel, and the line which passes through the flame, the hole, and the image will be a straight line, as may be determined by holding the plummet on one side of the vessel. Then let the glass vessel be filled with water; which done, it will be found that the image of the hole remains at exactly the same place in the bottom of the vessel. This shows that the light of the flame, passing through the hole in the card, and falling *perpendicularly* upon the surface of the water, proceeds in a straight line to the bottom of the glass vessel, without being at all refracted at the point where it enters the water.

Place a piece of money in the bottom of a common basin when empty; retreat from the basin till you just lose sight of the coin; then let some person pour water into the basin, and the object will gradually come into sight again, without your moving forward. This proves that light entering water obliquely is refracted.

If the vessel be filled with oil, or spirits of wine, or with any other transparent medium different from air, the ray of light entering it obliquely will still be bent, but more or less so according as one transparent medium or another is employed; which proves that transparent substances have different degrees of the refracting power.

It appears, from experiments, that denser bodies refract the rays of light more than those which are rarer. The refractive power of the diamond exceeds that of any other known substance; and to this property its peculiar brilliance, when properly shaped, is attributable, in a great degree. Among fluids, spirits of turpentine are the most refractive.

Rays of light are said to converge, when they tend to meet in one point.

Rays of light are said to diverge, when they proceed, separating from one another by increasing distances.

A lens is any transparent substance, fashioned in such a manner as to transmit the rays of light in some particular direction. Lenses for optical purposes may be of eight different shapes.

1. A plane glass. This is flat on both sides, and of equal thickness in all its parts.

2. A flat plano-convex. Its convex side is ground into several little flat surfaces.

3. A prism. This has three flat sides, and when viewed endwise appears like an equilateral triangle, and separates the rays of light as they pass through.

4. A concavo-convex, or meniscus. This is

convex on one side, and concave on the other, and is seldom used in optical instruments.

5. A plane, or single convex lens. This is plane on one side and convex on the other.

6. A double convex lens, convex on both sides.

7. A plano-concave lens. This is plane on one side, and concave on the other.

8. A double concave; concave on both sides.

A ray of light falling perpendicularly upon the surface of a plane glass, will pass through the glass in the same direction, and proceed in the same straight line.

A ray of light falling obliquely on a plane glass, will go out of the glass in the same direction, but not in the same straight line; for it will be refracted as it enters, and as it leaves the glass.

All the rays of light which fall upon a convex lens, whether parallel, converging, or diverging to a certain degree, will be made to meet in a focus on the other side; but if they diverge very much, they will not do so.

When parallel rays fall upon a concave lens, they will be made to diverge after passing through it.

QUESTIONS.

What is the science of Optics? How is this science generally divided? What are the principal opinions concerning the nature of light? How does it appear that the particles of light are astonishingly small? How does it appear that particles of light proceed from every point of the surface of a visible body, and in all directions? How is it evident that the particles of light move, naturally, in right lines? What is the velocity of the motion of light?

What is a ray of light? What is the refraction of light? How is a ray of light refracted, when it passes from a thinner into a thicker medium? How is a ray of light refracted, when it passes from a thicker into a thinner medium? What is the incident ray? What is the refracted ray? What is the angle of incidence, and what the angle of refraction? In what proportion does refraction diminish? What things depend upon the refraction of light? By what experiments is the refraction of light illustrated? What substance reflects the rays of light most? What is the converging of rays of light? What is the diverging of rays of light? What is a lens? How many kinds of lenses are there? How will a ray of light, falling perpendicularly upon it, pass through a plane glass? When a ray of light falls obliquely upon a plane lens, in what direction does it pass off? How is the direction of rays of light determined, when they fall upon a convex lens? How is the direction of rays of light determined, when they fall upon a concave lens?

CHAP. II.

OPTICS—continued.

VISION.

THE rays of light flowing from objects and passing through convex lenses, are collected into points, and form the images of external objects. Thus, the rays of light flowing from visible substances are refracted by the humours of the eye, and are thereby collected into innumerable points on the retina, where they form the images of the objects whence they flow. For the different humours of the eye are to be considered as a convex glass; and the rays of light, in passing through them, are affected in like manner as when they are transmitted through artificial convex lenses.

The eye is nearly globular, and consists of three coats and three humours. One part of the outer coat is called the sclerotica, and another the cornea. The coat next within this, and which is a kind of lining to it, is called the choroides, and joins to the iris, which is composed of two sets of muscular fibres, the one of a circular form, which contracts an orifice in the middle, called the pupil, when the light is too powerful; and of fibres which serve to dilate the pupil, when necessary. The third coat is a fine expansion of the optic nerve which spreads like a network over the inside of the choroides, and which is thence named the retina. Upon this are thrown the images of visible objects. Under the cornea is a fine transparent fluid, like water; thence called the aqueous humour. It has the same refracting power as water. At the back of this lies another fluid, called the crystalline humour. This is shaped like a double convex lens, and converges the rays which pass through it at the bottom of the eye. This humour, which is as transparent as crystal, is inclosed in a membrane, transparent likewise, called the capsule of the crystalline lens. At the back of the crystalline humour lies the vitreous humour, which is also transparent, and which fills the whole orb of the eye, giving it its globular shape. It is of nearly the same consistence as the white of an egg, and very little exceeds the specific gravity, and refractive power of water. As every point of a visible object sends out rays in all directions, some of those rays from every part of the surface presented to the eye, will fall upon the cornea, and by passing through the pupil and humours of the eye, they will be converged to as many points on the retina, and will form thereon a distinct inverted picture of the object; but the method by which this sensation is conveyed along the optic nerve to the brain and there discerned, is at present beyond the comprehension of human faculties. That vision is effected in this manner, may be shown experimentally.

If the three coats be removed from the back part of a bullock's eye while it is fresh, quite to the vitreous humour, and if a piece of white paper be placed over that part; then if the eye thus prepared be turned towards any bright object, an inverted picture of that object will be seen upon the paper. It is matter of wonder, that as the image is inverted, the object should appear upright. But it should be considered, that "inverted" is only a relative term; and that there is a great difference between the real object and the image by which it is perceived. When all the parts of a distant prospect are painted on the retina, they are all right with respect to one another, as well as the parts of the prospect itself; and we can judge of an object's being inverted, only when it is reversed as to its natural position with respect to other objects which we see, and to which we compare it.

The nearer any object is to the eye, the larger is the angle under which it is seen.

That part of the image which falls upon the middle of the optic nerve is lost, and consequently the corresponding part of the object is rendered invisible. This is shown by an easy experiment.

Let three patches be fixed upon a white wall, at the height of the eye, and at the distance of about a foot from each other; then, if a person placing himself before them shut one eye, and look with the other, the patch opposite to the optic nerve will disappear.

Vision is distinguished into bright and obscure; distinct and indistinct. It is said to be bright, when a sufficient number of rays enter the pupil at the same time; and obscure, when too few entêr. Vision is distinct when each pencil of rays is collected into a focus exactly upon the retina; it is indistinct, when the rays of light meet in a point, before they reach the retina, or when their point of meeting is beyond the retina.

When the cornea of the eye is too protuberant, the rays suffer a considerable refraction at their entrance into the aqueous humour, and are therefore collected into a focus before they arrive at the retina, unless the object be placed very near, so that the rays that enter the eye may have a great degree of divergency. This occasions what is called near-sightedness; and it is remedied by placing before the eye a concave lens, which causes the rays of light to diverge between it and the eye, lengthens the focal distance, and makes the rays unite at the retina and form a distinct image of the object.

If the cornea be too flat, the rays diverge too much before they reach the retina, and consequently the image they form there, must be indistinct. This occasions what is called long-sightedness, and is remedied by convex lenses, which cause the rays to converge sooner, and meet upon the retina, painting a distinct image.

Those eyes which have a proper degree of convexity, cannot see any object distinctly at a distance less than six inches; and there are numerous objects too small to be discerned at that distance.

An image of every visible object is painted upon the retina of each eye, and yet we do not see objects double. Sir Isaac Newton and others have endeavoured to account for this by the union or touching of the two optic nerves before they reach the brain.

Objects, when viewed by both eyes, appear brighter than when seen by one only. When one eye is closed, the pupil of the other is enlarged.

An object seen through a convex lens, appears larger, brighter, and more distant, than when seen by the naked eye.

An object viewed through a concave lens, appears nearer, smaller, and less bright, than when seen by the naked eye.

QUESTIONS.

How is the operation of vision performed? What coats and humours does the eye contain, and what effect do they produce upon the rays of light which are transmitted through them? In what situation is the image of a visible object painted upon the retina? If the images of objects be formed upon the retina inverted, how is it that we see them? What experiment shows that images of objects are painted inverted upon the retina? By what experiment is it shown that the part of an image which falls upon the middle of the optic nerve, is lost? When is vision said to be bright or obscure, distinct or indistinct? What occasions near-sightedness, and how is that defect remedied? How is far-sightedness occasioned, and how remedied? As images of objects are painted on the retina of each eye, how is it that we do not see them double? What difference of appearance of objects takes place when they are viewed with both eyes, or with one eye only? How do objects appear through a convex lens? How do objects appear through concave lenses?

CHAP. III.

OPTICS—continued.

REFLECTION OF LIGHT.—RAINBOW.—COLOUR.

When a ray of light falls upon any body, however transparent that body may be, the whole of the ray never passes through it, but some portion is always reflected. It is by this reflected light that bodies which have no light in themselves become visible. Of that part of the ray which enters, another part is also reflected from the second surface, or that which is farthest from the luminous body. When this part arrives again at the first surface, part of it is reflected back from that surface, and thus it continues to be reflected between the two surfaces, and to pass backwards and forwards within the substance of the medium, till some part is totally extinguished and lost. No body, therefore, however transparent, can transmit all the rays which fall upon it; neither, though it be ever so well fitted for reflection, will it reflect them all.

Refraction is supposed to be produced by an attractive power diffused throughout the medium, and extending a very little way beyond it; but with regard to the reflection of the rays of light, no satisfactory theory has been yet proposed, though, by various philosophers, various causes have been assigned for this effect.

The fundamental law of the reflection of light is, that the angle of reflection is always equal to the angle of incidence. This is found by experiment to be the case, and may be demonstrated mathematically from the laws of impulse, in bodies perfectly elastic. This axiom holds good in every case of reflection, whether it be from plane or spherical surfaces; and from it are deduced the seven propositions following.

1. Rays of light reflected from a plane surface, have the same degree of inclination to one another which their respective incidental rays have.

2. Parallel rays reflected from a concave surface, are rendered converging.

3. Converging rays falling on a concave surface, are made to converge more.

4. Diverging rays, falling upon a concave surface, are, after reflection, parallel, diverging, or converging.

5. Parallel rays, reflected from convex surfaces, are rendered diverging.

6. Diverging rays reflected from convex surfaces, are rendered more diverging.

7. Converging rays, reflected from convex surfaces, are parallel, converging, or diverging.

There is one thing peculiar to images by reflection; that each point in the representation of an object made by reflection appears situated somewhere in a right line, that passes through its correspondent point in the object, and is perpendicular to the reflecting surface.

When an object is seen by reflection from a plane surface, the image of it appears at the same distance *behind* the surface that the object is *before* it; of the same magnitude, and directly opposite to it.

When an object is seen by reflection from a convex surface, its image appears nearer to the surface, and less than the object.

When an object is seen by reflection from a concave surface, the representation of it is various, both with regard to its magnitude and situation, according as the distance of the object from the reflecting surface is greater or less.

DIFFERENT REFRANGIBILITY OF LIGHT.

Sir Isaac Newton discovered this property of light. In a darkened chamber, at a round hole, about one third of an inch broad, made in the shutter of a window, he placed a glass prism, whereby the beam of the sun's light, which came in at that hole, might be refracted upwards towards the opposite wall of the chamber, and there form a coloured image of the sun. He turned the prism slowly round its axis, and saw the refracted image of the sun, first to descend, and then to ascend. Between the descent and ascent, when the image seemed stationary, he stopped the prism, and fixed it in that situation. He then let the refracted light fall perpendicularly upon a sheet of white paper, placed at the opposite side of the room, and observed the figure and dimensions of the solar image, formed on the paper by that light. This image was oblong, and coloured. The more eminent colours lay in this order, from the bottom to the top; red, orange, yellow, green, blue, indigo, violet, with all their intermediate degrees in a continual succession, perpetually varying.

From this and other experiments, he concluded that the light of the sun consists of a mixture of several sorts of coloured rays, some of which, at equal incidences, are more refracted than others, and therefore are called more refrangible. The red is the least refracted of all the range, and the orange, yellow, green, blue, indigo, and violet, are continually more and more refracted, as they are more and more diverted from the course of the direct light.

Lights reflected from natural bodies of different colours differ also in refrangibility, and in the same manner as do the rays of the sun.

Colours in objects are dispositions to reflect certain kinds of rays more copiously than others.

In homogeneous light, vision is more distinct than in heterogeneous light. If the sun's light consisted but of one kind of rays, there would exist only one colour in the world, nor would it be possible to produce any new colour by reflections or refractions. The variety of colours depends entirely upon light's being a compounded substance.

Every homogeneous ray is refracted by one and the same rule; so that its sine of incidence is to its sine of refraction in a given ratio.

THE RAINBOW.

As the rainbow, whenever it is seen, appears opposite to the sun, it was naturally imagined that its colours were produced by some kind of reflection of the rays of light from the drops of rain. When Newton discovered the different refrangibility of the rays of light, he immediately applied the discovery to the phenomena of the rainbow, taking up the subject where his predecessors in the path of science had left the investigation imperfect. A ray of light, at its entrance into a drop of water, begins to be decomposed into its proper colours; and upon leaving the drop, after one reflection and a second refraction, it is farther decomposed into as many differently-coloured pencils as there are primitive colours in the light.

When the sun shines upon falling drops of rain, the rays that come from those drops to the eye of the spectator, after one reflection and two refractions, produce the primary rainbow.

The primary rainbow is never a greater arc than a semicircle.

When the sun shines upon falling drops of rain, the rays which come from those drops to the eye of the spectator, after two reflections and two refractions, produce the secondary, or outward rainbow.

The colours of the secondary rainbow are fainter than those of the primary, and are arranged in the contrary order.

OF THE CONCAVE FIGURE OF THE SKY.

The apparent concavity of the sky is only an optical deception, proceeding from the incapacity of our organs of vision, to take in very large distances. It has been demonstrated, that if the surface of the earth were perfectly plane, the distance of the visible horizon from the eye, would scarcely exceed the distance of five thousand times the height of the eye above the ground; and that beyond this distance, all objects would appear in the visible horizon. When the sky is overcast with clouds of equal gravities they will all float in the air at equal heights above the earth, and will compose a surface, resembling a large ceiling, as flat as the visible surface of the earth. Its concavity, therefore, must be merely apparent, and when the clouds are at unequal elevations, as their real shapes and magnitudes are unknown, the eye can seldom distinguish the unequal distances of those clouds that appear in the same directions, unless when they are very near, or are driven by contrary currents of air. So that the apparent figure of the whole surface, remains alike in both cases. And when the sky is partly overcast, and partly free from clouds, we have the same idea of its concavity, as when quite overcast.

The concavity of the sky appears to the eye, which is the only judge of apparent figures, to be a smaller portion of a spherical surface than a hemisphere. The centre of the concavity is much below the eye; and the distance of its parts at the horizon, is found to be generally between three or four times greater than the apparent distance of its parts overhead.

OF THE BLUE COLOUR OF THE SKY.

The first rational explanation given of this phenomenon, is, that it proceeds from a mixture of the white light of the sun with the black space beyond the atmosphere, where there is neither refraction, nor reflection. This opinion prevailed very generally at one time, maintained by the assertion that white and black may be so mixed as to produce blue. Another supposition concerning it is, that the blue colour arises from the constitution of the air itself; owing to which the fainter-coloured rays are incapable of penetrating through it, to any considerable distance. Hence it was concluded that the colour of the air is properly blue.

But the following appears to be the true explanation of the blue colour of the sky. The light which flows from any portion of the sky is obviously, reflected light, which is thrown out into the atmosphere, in all directions, by the earth, and the clouds and vapours that surround it.

The red, or least refrangible rays of this light, having a greater momentum than the blue, or most refrangible rays, penetrate much farther into the atmosphere; and though a few may be reflected, yet by far the greater part of them must be lost and absorbed, before they can return to the earth's surface. On the contrary, the blue rays having less momentum, are not capable of penetrating so far into a resisting medium, and are therefore reflected back to the earth's surface, and thus give a blue colour to the expanse of the heavens. The blue colour of the sky is exactly the converse of the red colour which is perceived at great depths in the sea, and of the red hue of the morning and evening clouds. These phenomena being produced by transmitted or refracted light, the red rays make their way through the medium to the eye of the observer, while the blue rays are reflected or absorbed.

QUESTIONS.

What is the reflection of light? What is the supposed cause of reflection? What is the fundamental law of reflection? What are the seven propositions deduced from the fundamental law of reflection? What is the peculiar property of images seen by reflection? How does the image of an object seen by reflection from a plane surface appear? When an object is seen by reflection from a convex surface, how does it appear? When an object is seen by reflection from a concave surface, what is its representation? What is the different refrangibility of light; and who discovered it? Into what coloured rays is a sun-beam decomposed by the prism; and how are those rays situated with respect to one another? Is there any diversity of refrangibility in rays reflected from natural bodies? What are colours in objects? In what kind of light is vision most distinct? What would be the effect, if the sun's light consisted only of one kind of rays? Upon what circumstance does the variety of colours depend? What is the cause of the rainbow, primary and secondary? How is the concave figure of the sky explained? What is supposed to be the cause of the blue colour of the sky?

CHAP. IV.

OPTICAL INSTRUMENTS.

THE PRISM, from the Greek word Prisma, something sawn or cut off. In geometry it is an oblong, solid body, contained under more than four planes, whose bases are equal, parallel, and alike situated. There are quadrangular and triangular prisms.

In Dioptrics, the prism is a glass in form of a triangular prism, which separates the rays of light in their passage through it. When used, it is placed in an aperture through which alone light is permitted to enter the apartment. It then decomposes the pencils of light as they are transmitted through it, and exhibits the primitive colours in their proper order, on any substance placed behind the prism.

Every triangular prism may be divided into three equal pyramids.

THE MULTIPLYING GLASS.

The multiplying glass is made by grinding down the convex side of a plano-convex glass, into several flat surfaces. An object will not appear magnified through this, but it will appear multiplied into as many different objects, as the glass contains plane surfaces. For since rays will flow from the object viewed through it, to all parts of the glass, and each plane surface, will refract those rays to the eye; the same object will appear to the eye in the direction of the rays which enter it through each surface.

MIRRORS.

Every polished body that reflects the rays of light, is called a mirror, whether its surface be plane, spherical, conical, cylindric, or of any other figure whatsoever.

Three kinds of mirrors are principally used in optical experiments, namely, the plane mirror, the spherical convex mirror, and the spherical mirror.

The point round which the reflecting surface of a spherical mirror is described, is called its centre. The line drawn from its centre perpendicular to its two surfaces, is the axis of the mirror; and the point to which that line is drawn is its vertex.

In a plane mirror, the image will appear as far behind the mirror, as the object is before it.

The object will appear of the same size, and in the same position as the object.

Every such mirror will reflect the image of an object of twice its own length and breadth. If the object be an opaque body, and its rays fall on the mirror nearly in direct lines, there will be only one image visible, which will be reflected by the inner surface.

If the object be a luminous body, and if its rays fall very obliquely upon the mirror, there will appear, to an eye placed in a proper position, several images; the first of which, reflected from the outer surface of the mirror, will not be so bright as the second, reflected from the inner surface. The following images, which are produced by the repeated reflections of the rays between the two surfaces of the glass, will be, in proportion, less vivid, to the eighth or tenth, which will be scarcely visible.

In a spherical convex mirror, the image will always appear behind it.

The image will be in the same position as the object.

The image will be less than the object.

The image will be curved, but not like the mirror itself, spherical.

Parallel rays falling on such a mirror, will have the focus, or image, at half the distance of the centre from the mirror.

If the rays falling upon it be converging, the distance of the object must be equal to half the distance of the centre, to make the image appear behind the mirror.

Diverging rays will have their image at less than half the distance of the centre. If the object be placed in the centre of the mirror, its image will appear at one-eighth of that distance behind it.

In a spherical concave mirror, that point where the image appears of the same dimensions as the object is the centre of that mirror.

Parallel rays will have their focus at one half the distance of the centre.

Converging rays will form an image before the mirror.

In diverging rays, if the object be at less than one half the distance of the centre, the image will appear behind the mirror, erect, curved and magnified; but if the distance of the object be greater, the image will be, before the mirror, inverted and diminished.

The sun's rays falling on a concave mirror, and being parallel, will be collected in a focus, at half the distance of its centre, where their heat will be augmented in the proportion of the surface of the mirror to that of the focal spot.

This shows by what means the sun's rays falling upon a glass spherical decanter, have set fire to furniture.

If a luminous body be placed in the focus of a concave mirror, its rays being reflected in parallel lines, will strongly enlighten a space of the same dimension with the mirror, at a great distance.

If the luminous object be placed nearer than the focus, its rays will diverge, and consequently enlighten a larger space. On this principle reverberating lamps are constructed, in order to increase the intensity of light.

If a man place himself directly before a large concave mirror, but farther from it than its centre of concavity, he will see an inverted image of himself in the air, between him and the mirror, and of a less size than himself. If he hold out his hand towards the mirror, the hand of the image will come out towards his hand, and coincide with it, of an equal bulk, when his hand is in the centre of concavity; and he will imagine that he may shake hands with his image. If he reach his hand farther, the hand of the image will appear to pass by his hand, and come between it and his body. If he move his hand toward either side, the hand of the image will move towards the other. Whatever way the object moves, the image will move the contrary. All the while, a bystander will see nothing of the image, because none of the reflected rays which form it enter his eyes.

By the skilful management of these mirrors extraordinary optical illusions are produced, many of which have, in past ages of ignorance, been considered as supernatural effects, and have been used to impose upon the weak and superstitious, and to accomplish the purposes of interested, designing men.

False appearances of fortifications of immense extent; surprising multiplication of objects; opaque bodies seemingly rendered transparent; images of different faces reflected from a glass; landscapes extended to an amazing degree; combustible bodies set on fire at a considerable distance; deceitful apparitions of flowers and fruits eluding the grasp; threatening swords and daggers; and apparitions of deceased friends, are among the effects of the different kinds of mirrors artfully applied.

THE CAMERA OBSCURA.

Make a circular opening in the shutter of a window. In this opening place a convex lens, either double or single, whose focus is at the distance of three feet, or more. Let no light enter the chamber but through that glass. At a distance from it, equal to that of its focus, place a piece of pasteboard, covered with the whitest paper, having a black border, to prevent any of the side rays from disturbing the picture. Let the pasteboard be two feet and a half long, and eighteen or twenty feet high. Bend the length of it inwards, to the form of a part of a circle whose diameter is equal to double the focal distance of the glass. Then fix it on a frame of the same figure, and put it upon a moveable foot, so that it may be easily fixed at that exact distance from the glass, where the objects will be represented most accurately. When thus placed, all the objects which are opposite the window, will be painted on the paper, in their exact forms and colours, but inverted as to position. If a moveable mirror be placed outside the window, by turning it more or less, the objects which are on each side of the window may be successively represented on the paper. If the mirror be within the chamber, and above the opening in the window-shutter, which must then be nearly at its top, the images of external objects may be depicted on paper lying horizontally upon a table, and may thus be accurately traced with a pencil.

A room thus prepared is called camera obscura, the darkened chamber.

The lights, shades, and colours of external objects, appear in the Camera Obscura not only just, but also much stronger than in nature, by the images being diminished. These pictures, formed by the Camera Obscura, exceed all other pictures, because they represent the movements as well as the figures and colours of objects.

Convenient portable machines, producing these effects, are now contrived, being boxes, on the upper lid of which, made of glass, rough on the outer surface, the picture is thrown, whereby any landscape or edifice may be accurately delineated. These boxes are made to fold together, so as to be easily carried in the pocket.

THE MAGIC LANTERN.

This machine, which is at present well known, but which excited great astonishment when first exhibited, is said to have been invented by the celebrated Kircher. Its design is to represent on paper, board, or a white wall, in a darkened chamber, the magnified images of small objects, painted with transparent colours on plates of glass.

The construction of the magic lantern is as follows: A tin box is prepared, having a funnel at its top, with a cover; so that while it gives a passage to the smoke of a lamp which is within the box, prevents the light from issuing forth through that opening. The lamp, which is low, is placed in the middle of the bottom of the box, and is moveable. In the front of the box is a large tube, having a smaller one sliding in it. In the larger tube is a glass, semi-globular, or half a globe; in the smaller, a double convex lens. The lamp is placed level to the centre of the glasses in the tubes. The smaller tube is made to slide in the larger, in order to adjust it at such a distance from the glass sliders as that the objects painted on them may be distinctly represented upon the paper or other receiving substance. The glass sliders are placed in a groove, or slit, made in the lantern for that purpose, just behind the large tube; and the chamber being darkened, a quantity of light from the lamp will be collected by the lens of the larger tube, and refracted upon the paper or wall opposite; then by moving the sliding tube, containing the small double convex lens, gradually in or out, as occasion may require, this lens will transmit the images of the figures painted on the sliding glasses, in their distinct colours and proportions, and of any size, according to the distance of the lantern from the paper or wall. An apparatus has been contrived, which, being applied to this machine, converts it into a microscope by night.

THE MICROSCOPE.

The microscope is an optical instrument, consisting of lenses, or of mirrors, by means of which small objects appear larger than they do to the naked eye.

Single microscopes are such as consist of a single lens or mirror; or, if more lenses or mirrors be used, they are used merely to throw a stronger light on the object, and to contribute to the magnifying of its image.

The single is the simplest of all microscopes, being nothing more than a small globule of glass, or a convex lens, whose focal distance is extremely short.

Of these there are several kinds, adapted to different purposes.

The single microscope, by reflection, which has a concave mirror, that by throwing a strong light on the object examined, greatly aids its accurate examination.

The single opaque microscope, which remedies the inconvenience of having the dark side of an object turned towards the eye, by means of a concave speculum of silver highly polished, in whose centre is placed a magnifying lens.

The single aquatic microscope, for the more accurate observing of animalcula; and especially aquatic substances and animalcula.

The single microscope for botanical observations.

The single anatomical dissecting microscope.

Double or compound microscopes are such as consist of a combination of two or more lenses.

The particular advantages which the double microscope possesses over the single microscope, are, that, by the former, objects are represented in a larger field of view, and possess a greater amplification of reflected light. Of these there are likewise many different sorts possessing their several advantages.

THE SOLAR MICROSCOPE.

The solar microscope is composed of a tube, a looking-glass, or mirror, a convex lens, and a single microscope. The sun's rays being reflected, by means of the mirror, through the tube upon the object to be examined, the image of it is thrown distinctly and beautifully upon a screen of white paper, or any other white and smooth substance, placed in a proper situation to receive it, which image may be magnified to an amazing degree. The farther the screen is removed the larger does the object appear; so that a flea may be magnified to the length of five or six feet. When this microscope is employed, the chamber must be darkened as much as possible; for on the darkness of the room, and the intensity of the light reflected upon the object, depends the accuracy of the image. The same object may be variously magnified, by the application of different lenses. The degree of the magnifying power is determinable by the following rule: "As the distance of the object is to that of its image from the magnifier, so is the length or breadth of the object to that of the image."

THE LUCERNAL MICROSCOPE.

The great facility with which objects can be represented on paper, or rough glass, by the Camera Obscura, suggested the application of the microscope to that instrument. This is so completely done, that by candle or lamp-light, even opaque objects may be examined with the greatest exactness. The beautiful colours with which many of them are adorned are rendered more brilliant, without affecting their real tints; and concave and convex parts, also, retain their proper forms. TheLucernal Microscope does not, in the least, fatigue the eye. The objects appear as in nature, giving ease to the sight instead of straining it. This instrument may be used by day-light, though its most powerful effects are produced by night.

QUESTIONS.

What is the multiplying glass? What are mirrors? How do objects appear reflected from a plane mirror? From a spherical convex mirror? From a spherical concave mirror? What effect is produced by the sun's rays falling parallel upon a concave mirror? What is the centre of a spherical concave mirror? How will converging rays, reflected from a concave spherical mirror, form the image? How will diverging rays, reflected from a spherical concave mirror, form the image? If the luminous object be placed nearer to the spherical concave mirror than the focus, how will the rays be reflected? What instruments are constructed upon this principle? What effects will be produced, if a man place himself before a large concave mirror, farther from it than the centre of its concavity? What optical illusions have been produced by the skilful management of concave mirrors? What is the Camera Obscura? What is the Magic Lantern? What is the Single Microscope? The Compound Microscope? The Solar Microscope? The Lucernal Microscope?

CHAP. V.

ACOUSTICS.

LAWS OF SOUND. — ECHO.

The science which contemplates the nature and laws of sound, is termed Acoustics, a name borrowed from the Greek word, signifying to hear.

Sound, the immediate external object of the sense of hearing, is defined to be a particular agitation of the parts of surrounding bodies, acting by mechanical impulse upon certain organs, adapted to receive impressions from them, by the infinite wisdom of the great First Cause; or, sound is the impression made by an elastic body, upon air or water, and conveyed by either fluid to the organ of hearing.

Air is the general instrument of the conveyance of sounds to the human ear. Without the medium of this, or some other fluid, there would be no sounds at all.

If a bell be shaken in the exhausted receiver of an air-pump, it will emit no sound; it will ring under the receiver, before the pump is worked; but, as the air is drawn off, the sound proportionately grows weaker, till, finally, its strongest vibrations are scarcely distinguishable.

Thus it is proved that air is a vehicle for sound; but air is not the only vehicle which can convey those impressions; for water communicates them with equal facility. A bell swung in water produces as distinct a sound, as when it is stricken in air; and it appears, from experiments, that fishes have a strong perception of sounds at a great depth of water.

But, though air and water are both vehicles of sound, yet, according to some philosophers, neither of them is so by itself; but is rendered so by means of an exceedingly subtle fluid capable of penetrating the most solid bodies. By the medium of this subtle fluid, sounds can be propagated through wood or metals, more readily than even through the open air. Thus deaf persons may be made sensible of sounds by holding in the mouth a metal rod, one end of which is applied to the sounding body.

Whether sound be conveyed through air or water, in undulations, or in circles beyond circles, like the waves of water, when the smoothness of its surface is disturbed by a stone, or other weighty substance, or whether it travel along, like rays diffused from a centre, as the electrical fluid runs along a rod of iron, are questions of dispute. Newton was of the first opinion, and explains the progression of sound, by an undulatory, or rather a vermicular, motion in the parts of the air.

It has been found by experiments that sound travels at the rate of about 1142 feet in a second, or nearly thirteen miles in a minute. The progress of sound is easily ascertained. When a gun is discharged at a distance, the flash is seen, before the report is heard. If then, the distance be known, and the time which has elapsed between seeing the flash and hearing the report be determined, it will appear how long the sound has been in passing through such a distance. Thus, if the distance of the gun discharged be a mile, and the seconds be counted, by means of a stop-watch, which elapse between seeing the flash and hearing the noise, that number of seconds will be the time the sound has taken to travel a mile. Thus may be found the distance between objects, which could be measured no other way. For instance, if the flash of a gun be seen in the night, at sea, and seven seconds are reckoned, before the sound reaches the ear, it follows that the distance of the gun is seven times 1142 feet, or twenty-four yards more than a mile and a half. In like manner, if the number of seconds be observed, which pass between the seeing of a flash of lightning, and the hearing of the thunder, the distance of the cloud, whence it proceeds, will be known.*

Derham proved by experiment, that all sounds move with the same velocity. The report of a cannon, and the sound produced by striking upon any elastic body, as with a hammer upon an anvil, are equally swift in their movements. The softest whisper, as far as it goes, flies as swiftly as the loudest thunder.

From bodies that are of a uniform figure, smooth and clear sounds proceed; while the sounds, proceeding from bodies of mixed material and irregular figure, are harsh, or obtuse.

The velocity of sounds is to that of a brisk wind, as fifty to one.

The strength of sounds is greatest in cold and dense air, and least in that which is warm and rarefied. Thus Captain Parry in his first northern expedition, when in air of very cold temperature, heard the voices of some of his crew, in the common tones of conversation, at the distance of a mile. Every point against which the pulsations of sound strike, becomes a centre, from which a new series of pulsations are propagated in every direction.

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* The pulse of a young and healthy person beats nearly about once every second; therefore, if such a person count the beatings of his pulse between a flash of lightning and the following thunder-clap, and find them to be six, he may be sure that the cloud whence the electrical flash proceeded, is about a mile and a quarter distant 1142 × 6=6852 feet equal to 2117 yards, one mile 380 yards.

Sound describes equal spaces in equal times.

Sound, after it has been reflected from many points, may be collected in one point, as into a focus, and it will be more audible there, than in any other part; even than at the place whence it first proceeded. Upon this principle, whispering galleries are constructed, and various astonishing effects are produced.

Speaking trumpets augment the strength of sounds, by reflecting them from the elastic tremulous sides of the metallic tubes of which they are composed.

Hearing trumpets, by collecting the undulations of sound into a small compass, cause them to strike more forcibly upon the drum of the ear.

An Echo, is sound reflected back from some object against which it strikes, just as the image of any body, placed before a mirror, is reflected from its surface.

As every point against which the pulses of sound strike, becomes the centre of a new series of pulses, and as sound describes equal distances in equal times, therefore when any sound is propagated from a centre, and its pulses strike against a variety of obstacles, if the sum of the right lines drawn from that point to each of the obstacles, and from each obstacle to a second point, be equal, then will the latter be a point, in which an echo will be heard.

In order to hear the echo of his own voice, a man must stand, at least, sixty-three, or sixty-four feet distant from the reflecting obstacle. In general, the distance of the speaker from the echoing surface, for any number of syllables, must be equal to the seventh part of the product of 1142 feet, multiplied by that number.

Upon these principles are founded a number of amusing contrivances and experiments, such as the conversing statue, which appears to return answers to questions put to it; the communicative busts, by which a person whispering into the ear of one bust, is distinctly heard by any one who places his ear to the mouth of the other bust, without being heard by any intervening person; the oracular head, which seems to make rational replies to interrogations; and the invisible lady. Music is the art of combining sounds so as to afford pleasure to the hearers. It may be regarded as consisting of two branches, melody and harmony. Melody is produced by the arrangement of sounds in succession. Harmony is produced by the combination of several sounds generated at the same time. When properly managed, both are capable of exciting agreeable sensations in the mind.

The charms of melody have been known and felt in almost every age and nation. Harmony has never been so universally known, and has not been brought to perfection till modern times.

Melody is a series of sounds which succeed each other in a manner pleasing to the ear.

A chord is a combination of several sounds heard together; and harmony is properly a series of chords, producing a similar effect.

An interval in melody or harmony, is the distance, or difference in pitch, between one sound, and another, higher or lower than it.

If two strings of equal length, thickness, and tension be made to vibrate together, they will yield exactly similar sounds, or, as it is called, be in unison.

Two tubes of the same length and diameter, when stricken by the air with sufficient force, will produce unison sounds.

If a sonorous string be divided into two equal parts, the sound of each half will be an octave, that is, eight notes higher than the tone of the whole string would be.

Long strings, and pipes of large diameter, produce deep sounds; short strings, and pipes of small diameter, yield acute and high tones.

QUESTIONS.

What is the science of Acoustics? What is sound defined to be? What substances are good conveyers of sound? What experiment proves that air conveys sound? How is it proved that wood and metal will convey sound? What was Newton's opinion concerning the direction in which sound moves? At what rate does sound travel? How is the progress of sound ascertainable? From what different bodies do smooth or clear sounds, and harsh or obtuse sounds proceed? When is the strength of sounds greatest? What is the general law of the movement of sound? What is the law of sound striking against points? Upon what principle are whispering galleries constructed? How do speaking and hearing trumpets act? What is an echo?

How far must a person be from the opposing obstacle, in order to hear the echo of his own voice? What contrivances and curious machines are founded upon these principles? What is music defined to be? What is melody? What is harmony? What is a chord? What is an interval? How are unison sounds produced? How are octaves produced? What kinds of strings and tubes produce acute and high, and what kinds generate deep sounds?

CHAP. VI.

ELECTRICITY.

ELECTRICITY is the name of an unknown natural power, which produces a great variety of peculiar and surprising phenomena. The first of those phenomena were supposed to have been observed in a substance called amber; and from *electron*, the Greek word for amber, is derived the term electricity. If a clean and dry piece of amber, or of glass, be rubbed briskly with a dry hand, and be presented to small light bodies of any kind, such as particles of paper, straw, or feathers, it will first attract them, and, after having retained them in contact with it for some time, will repel them. This alternate attraction and repulsion will continue until the power entirely ceases. If this experiment be made in a dark room, luminous sparks will be perceived passing between the glass, or amber, and the small bodies which are attracted and repelled. If, after rubbing a tube of glass, closed at one end, the knuckle be presented to the closed end, a crackling or snapping noise will be heard, and the finger will receive a slight shock. In this experiment, the glass, or the amber, is said to be electric, that is, capable of acquiring such qualities; and when they are imparted to it by friction, it is said to be excited. The attraction and repulsion, which differ from all other kinds of attraction and repulsion, together with the sparks, and the crackling noise, are called electrical phenomena. The hand which has excited the electric by its friction, is called the rubber; and when a machine is constructed which contains the electric and a rubber, so disposed that, by an easy motion, the former may be conveniently excited by the friction of the latter, this is named the electrical machine. If to the amber, or the glass, a wire be affixed, having a metallic ball at its end, and the amber, or glass, being first excited, this wire be so suspended as that the metallic ball be presented to light bodies, an alternate attraction and repulsion will take place between the light bodies and the ball, exactly as it took place between the electric and the light bodies; the electric virtue, therefore, must in this case, pass through the wire, and be imparted to the metallic ball, and hence the wire is said to be a *conductor* of electricity.

If the last experiment be repeated, making use of a silk string, instead of a wire, the light bodies will not be attracted and repelled by the ball. This shows that the electric virtue will not go through silk; and silk is, therefore, called a non-conductor of electricity.

All bodies with which we are acquainted are, in various degrees, conductors or non-conductors of electricity. A body entirely surrounded by non-conductors, is said to be insulated. Thus a piece of metal suspended in the air by a silken string, is insulated, because the silk and the air, the only bodies which touch it, are non-conductors.

Some bodies are rendered electrical by heating and cooling; others by coagulation. Certain effervescences, and evaporation or the conversion of water into steam, and the condensing of steam, or the re-converting it into water, also produce electricity. The ambient air, the clouds, with the rain, snow, and hail that fall from them, and fogs, are generally electrified in various degrees. Thunder and lightning are electric phenomena, arising from the electricity of the clouds; and their electricity appears to be produced by evaporation, and condensation of vapour.

A remarkable electrical power is possessed, likewise, by four animals, inhabitants of the sea; the torpedo, the gymnotus electricus, the silurus electricus, and another fish, which has not yet been sufficiently examined to receive a name.

Electricity is also produced by a peculiar disposition of certain metallic substances in a particular order, other substances being interspersed between them. This mode of producing electricity is of modern discovery, and is commonly known by the name of Galvanism.

When a rounded body, a metallic globe, for instance, is presented to the excited electric, the fire appears to dart from it in a spark; but if the presented body be pointed, the fire will be seen to issue in a stream of luminous rays.

These rays will take a different direction, according to the substance with which the electric is rubbed, and other circumstances. If a pointed body be presented to a glass tube rubbed with the hand, the luminous rays will appear like a star around the point. The same appearance will take place on presenting a point to a stick of sealing-wax, rubbed with any metallic body; but when the sealing-wax is rubbed with woollen cloth, the rays will appear to issue from the point, in a pencil diverging towards the wax. These different appearances have been attributed to two different states of the electrical power; and these states have been called the two electricities.

As in the former case the fire seems to flow from the glass into the metallic body, as if there were an excess in the former; the glass is said to be electrified *plus*, or positively, and this is called positive electricity. In the latter case, as the stream appears to flow from the point into the sealing-wax, as if there were a deficiency in the latter, the sealing-wax is said to be electrified *minus*, or negatively; and this is called negative electricity. As when glass is rubbed with most substances, positive electricity is excited, and negative electricity is excited when resinous bodies are rubbed with most substances; the former is often called vitreous, and the latter resinous electricity.

When any body, whether electric or conductor, is made to exhibit electrical phenomena, either by being excited, or by communication, it is said to be electrified.

When an electric is once excited, it will retain the electric power for a longer or shorter time, according to its situation and nature. If it communicate freely with conductors, it will lose it the more quickly in proportion as these are more perfect; but if it be insulated it will continue in an electrified state for a considerable time.

Electrics may be excited in various ways, the greatest number of them by friction, as glass, silk, sulphur, amber, sealing-wax; and some by heating and cooling, as the tourmaline, a species of mineral belonging to the siliceous kind.

Dust or moisture is found to diminish the excitability of electrics; but oil or any fat substance increases it.

Most of the phenomena of electricity, and its grandest effects, are produced by the transition of the electrical fluid from one body to another; such as the light, the hissing and crackling noise, and the atmospherical lightning. By its rapid passage it melts metallic bodies, sets fire to inflammable substances, destroys animal and vegetable life.

When a body is electrified, that power is confined upon it only by electrics, and it remains upon that body a longer or shorter time, according as the electrics which confine it are more or less perfect. If any conductor be presented to an excited electric body, it will receive a spark from that body, which spark consists of a certain portion of the electricity of that electric.

If a conducting body, not insulated, be exposed to an excited electric, at a moderate distance, it acquires on the side so exposed the electricity contrary to that of the electric. This electricity grows stronger in proportion as that body is brought nearer to the electric, till at last the conductor receives a spark from the electric, by means of the attraction existing between the two electricities, and thus the balance is restored, and the conductor becomes possessed of the same kind of electricity as the electric. These effects will take place likewise, when some other non-conducting substance, besides air, is interposed between the excited electric and the conducting body, such as a thin plate of glass, or of resin, &c.; but in this case no spark can pass from the excited electric to the conductor, unless it force its way by bursting the interposed non-conductor.

The noise of the spark arises from its suddenly displacing the air which is interposed between the excited electric and the conductor which is presented to it.

It is proved, by a variety of facts, that the two kinds of electricity, the positive and negative, or vitreous and resinous, always accompany each other.

The experiments made with the electric spark gave the idea to several philosophers that electricity and lightning are the same thing. Dr. Franklin, the celebrated American philosopher, verified this idea. During a thunder storm he raised a kite, and the end of the string was fastened to a key. After a considerable time had elapsed, and he was beginning to despair of the effect, he saw the loose threads of the hempen string stand erect, and presenting his knuckle to the key, he obtained from it an electric spark. Others succeeded even before the string was wetted, but, when the rain began to descend, he collected the electric fire in abundance. Afterwards, by means of an insulated iron rod, he drew the lightning into his house, and performed with that natural electricity almost all the experiments which had been performed with electricity collected by artificial methods.

Upon this principle he recommended conductors to be constructed for the safety of buildings — metallic rods, which, being erected near houses, and reaching some feet above them, might convey the electric fluid from the clouds, without noise or danger, into the earth or water. These are in very general use, in countries where violent storms often take place, and have probably saved many edifices from being shattered by the passing of the electricity from electrified clouds. The noise of the thunder is occasioned by the rapid transmission of the lightning displacing a quantity of air, and other air rushing in to fill the void.

QUESTIONS.

What is electricity? What is an electric? What is a conductor? What is a non-conductor? When is a body said to be insulated? How is electricity excited in electrics? What meteoric phenomena are accompanied with, or are occasioned by, electricity? What animals possess a remarkable electrical power? What are two different states of the electrical power? How are most of the electrical phenomena produced? What effects are produced by the rapid transmission of the electrical fluid? When a body, not insulated, is exposed to an excited electric, what kind of electricity will it acquire? How is the electrical spark given and received? Whence arises the crackling noise heard when the spark is transmitted? How was electricity proved to be the same as lightning? What occasions thunder?

CHAP. VII.

ELECTRICITY — continued.

The principal conductors of the electric fluid are, stony substances in general; limestone, marble, oil of vitriol, allum, charcoal, all kinds of metals and ores, fluids of animal bodies; all fluids, excepting air, and oils.

The principal electrics, or non-conductors, are, amber, glass, sulphur; all precious stones, all resinous compounds, all dry animal substances, such as silk, hair, wool, &c.

The chief instruments used in producing and transmitting electricity are, tubes of glass, or cylinders of sealing-wax, which being well rubbed, collect and communicate the electrical fluid; cylinders or plates of glass, turned rapidly by means of a wheel, against a cushion or rubber, covered with amalgama or quicksilver killed; metallic conductors, or substances charged with humidity; electric bottles or jars, commonly called Leyden phials; electric batteries.

The electrical machine, now chiefly used, consists of a cylinder, or sometimes a circular plate of glass, turned by a handle and pressed against a rubber, which is supported by a glass pillar. This glass cylinder, by its friction against the amalgamated cushion or rubber, collects the electric fluid from surrounding objects, and communicates it by pointed wires to a prime or positive conductor, made of metal or wood, covered with tinfoil, and supported also by a glass pillar. Another conductor, called the negative conductor, is placed behind the cushion. A metal chain is attached to the rubber, to assist in collecting the electricity, and a screw to regulate the pressure of the cushion against the cylinder. Over the cylinder, a piece of silk is commonly placed.

The Leyden phial is a glass jar, coated on the inside with tin foil, to within an inch or two of the top, and closed with some electric substance, through which is introduced into the phial a wire, at whose external end is a metal knob. Presenting this phial to the prime conductor, the cylinder being worked, the inside of the phial is quickly charged, through the wire and knob, with a superfluous quantity of the electrical fluid, while the external surface of the glass is deprived of its proper quantity; the one side being positively, the other negatively electrified. As soon as a communication is formed by any conducting substance, between the inside and the outside of the glass jar, the electrical fluid rushes, with an explosion, from the internal to the external surface, and gives a shock to the conducting substance, through which it is transmitted.

An electrical battery consists of a number of Leyden phials, so connected by metal rods as to be charged and discharged together; by which means the power of the electrical shock may be augmented to such a degree as to kill animals like lightning, and to melt metals.

The motion of the electrical fluid is so rapid as to be scarcely perceptible. If any number of persons take hands and receive a shock together, the last through whom it passes will perceive it at the same instant with the first. It has been made to pass through the river Thames, and set fire to spirits on the other side, without any sensible lapse of time. It was transmitted through a circuit of four miles, crossing a river twice in its progress, and yet it's transmission appeared to be instantaneous.

Very extraordinary and powerful effects may be produced by the electrical battery; such as the exploding of gunpowder, the making iron wire red hot in an instant, and even melting it.

Besides thunder and lightning, the Aurora Borealis, or northern lights, and various other meteoric effects, are attributed to electricity, and it is closely connected with volcanoes and earthquakes.

If the face, or any other part of the body, be exposed, within a small distance, to an excited electric, or to a conductor strongly electrified, it will feel a peculiar sensation, as if a spider's web were drawn over it. If the nostrils be so presented, a peculiar smell will be perceived, resembling that of phosphorus; and if a body be kept some time within these effluvia, it will retain that smell for some minutes after. If the tongue be exposed to a stream of the electrical fluid, issuing from an electrified body, it will be affected with a slight, but peculiar kind of subacid taste.

It was long imagined that electricity, communicated to animal and vegetable bodies, accelerated the pulsation of the former, and promoted the growth of the latter; and though this be at present doubted, yet electrization, in cases of palsy, of nervous disorder, and of some other diseases, has been useful, as a safe and active stimulant. It is found, that at a small distance from the ground, from houses, trees, &c. the air is always electrified, and generally with positive electricity; but not always in an equal degree.

QUESTIONS.

What are the principal conductors of the electric fluid? What are the principal electrics, or non-conductors? What are the chief instruments used in producing and transmitting electricity? Of what does the electrical machine, now commonly in use, consist? What is the Leyden phial, and what is its operation? What is the electrical battery, and what effects does it produce? Does the electrical fluid pass with great rapidity? With what meteoric phenomena is electricity connected? What are the effects produced by approaching the hand, or the nostrils, or tongue, to an excited electric? With which kind of electricity is the air near the earth, near buildings, or trees, electrified? To what medical purposes is electricity applied?

CHAP. VIII.

GALVANISM.

GALVANISM is regarded as a branch of electricity, or electricity in a peculiar state, comprising all those electrical phenomena which arise from the chemical agency of certain metals with different fluids. It received its name from its discoverer, Galvani, of Bologna.

If two pieces of metal, the one of zinc, and the other of silver or copper, be so placed that the one shall touch the upper surface of the tongue, and the other touch its under surface, while the edges project over the point or tip, then, as often as the edges of the metals in this situation are brought into contact, a peculiar sensation is produced in the tongue; something like a slight shock of electricity takes place, and at the same time an austere, astringent, or metallic taste is excited. If a piece of tin foil be placed on one of the eyes, and a bit of copper held between the teeth, or touching the tongue, and a communication between the tin-foil on the eye and the copper on the tongue be established, by means of a wire, a flash of light is seen; and this effect takes place as often as the communication is completed. But if metals of the same kind be used in the experiment, no such effects are produced.

If a pile of a certain number of pairs of plates of zinc and silver, or zinc and copper, be arranged in a regular series, with pieces of cloth, moistened in a solution of common salt, placed between each pair; and if one hand, previously wetted with water, touch the lower pair, and the other hand, wetted also with water, touch the upper pair of plates, the moment that the communication between the bottom and the top of the pile is thus made, a smart shock is felt. A pile of this kind, consisting of forty pairs of plates, possesses the power of giving a shock, similar to that of a small electrical jar. This is called the Voltaic pile, from an Italian philosopher named Volta, who discovered, in the year 1800, this mode of accumulating the effects of this species of electricity.

From the peculiar effects of the Galvanic power upon animals, and from its producing wonderful muscular movements in dead animals, it was at first called animal electricity.

The strength of the Voltaic pile depends on the number of series of plates and vessels employed. Fifty or sixty pairs of plates are as many as can be conveniently erected in one pile; but to increase the power of the Galvanic fluid, a number of piles may be connected together. If the circle be completed, or the communication between the extremities of the pile be formed by means of charcoal, a spark is produced. This is done by attaching a piece of well-prepared charcoal to a wire which communicates with one extremity of the apparatus, and another similar piece of charcoal to another wire, communicating with the other extremity; then if the two pieces of charcoal be brought into contact, and the circle be thus completed, a spark will be transmitted from one to the other; and this may be repeated as long as the activity of the pile continues.

By this means, metals are made to burn and melt, and water is decomposed; and the muscles of dead men have been so excited as to exhibit strong movements of the limbs, and frightful convulsions of the face.

From various experiments are deduced the following inferences concerning Galvanism:

That it exerts a considerable power over the nervous and muscular systems, and operates universally on the animal economy.

That the power of Galvanism, as a stimulant, is stronger than any mechanical action whatever.

That the effects of Galvanism on the human frame differ from those produced by electricity through the instrumentality of common electrical machines.

That the action of Galvanism on the heart is different from that which it exerts on other muscles; for when the heart is no longer susceptible of Galvanic influence, the other muscles continue still excitable for a certain time.

That Galvanism affords very powerful means of restoring activity to the vital principle in cases of suspended animation, under common circumstances.

From batteries, composed of two or three hundred plates, very powerful shocks may be taken; and violent contractions may be thereby produced in the limbs of recently-killed animals. By a battery of such extent, convulsions so strong were produced on the limbs of horses, as scarcely to be restrained by the strength of two persons. On the head of an ox, strange effects were produced. The eyes opened, and the pupils were greatly dilated; the ears were put in motion; and the tongue, which had been drawn out of the mouth, and fixed down to the table by an iron skewer, was retracted with such force, as to pull the skewer from the table and throw it up to a considerable height in the air.

The chemical effects of Galvanism are no less extraordinary. It is made to burn charcoal; to decompose water, oil, alcohol, ether, and ammonia in solution; to deflagrate and melt many metallic substances; to precipitate metals from their solutions in acids.

By means of this power, the celebrated chemist, Sir H. Davy, decomposed soda and potash, and found their bases to be a very inflammable metallic substance.

By means of Galvanism, muriatic acid and soda have been formed.

As Galvanism produces such powerful effects upon the nerves and muscles, it is inferred, that it may be used with efficacy and benefit in nervous and muscular affections.

QUESTIONS.

What is Galvanism, and whence did that science receive its name? How is the Galvanic influence manifested? What is the Voltaic pile? What was Galvanism called at first? Upon what does the strength of the Voltaic pile depend? How is the spark produced from the Voltaic pile? What effects are produced by Galvanism on the animal system? What are the chemical effects of Galvanism? To what salutary purposes may it be applicable?

CHAP. IX.

MAGNETISM.

COMPASS.

Magnetism is that unknown power, which is either inherent in the magnet or loadstone, an ore of iron, or which is imparted to it by certain processes to which it is subjected. If the mineral body, called magnet, be brought within a moderate distance from a piece of iron, or any ferruginous body, that ferruginous body will approach the magnet, and if no obstacle intervene, will come into contact with it, and the two bodies will adhere together so as to require some force to separate them.

Again, if a magnet be balanced so as to be left at liberty to assume any direction ; for instance, suspended upon a thread, or floating on the surface of water upon a piece of cork or wood, or fixed upon a pivot so as to turn easily, it will turn one part of its surface towards the northern, and the other towards the southern point of the horizon. These two parts of the surface of the magnet, are called its north and south poles, and its property of thus directing itself, is called its polarity, or directive power ; and when a magnet arranges itself in this manner, it is said to traverse.

The direction in which a suspended magnet finally settles, is called the magnetic meridian. This is different in different places and at different times. It is generally, however, different from the real meridian line, so that the north pole of a magnet declines a little towards the east or west, and its south pole, a little towards the west or east. This is called the declination or variation of the magnet.

If an oblong magnet be suspended on a pivot by its centre of gravity, it does not settle in a position perfectly horizontal, but one of its poles sinks below the horizontal line, and then rises as far above it, making an angle with the horizon, which is different on different parts of the earth's surface. This depression of one of its poles, is called the dipping of the magnet.

If two magnets freely suspended, be brought within a moderate distance from each other, so that the north pole of the one is opposed to the south pole of the other, they will attract, and rush together if no obstacle intervene. But if the two north poles, or the two south poles be mutually opposed, the magnets will repel each other.

Any piece of iron or steel, by being rubbed with a natural magnet, may be endued with the properties of that magnet, and will then serve all its useful purposes. Pieces of iron thus magnetised, are called artificial magnets; and when they are made long and slender, they are called magnetic needles.

A straight line joining the two poles of a magnet, is called its axis.

A right line drawn transversely on the surface of a magnet, and perpendicular to the axis, is called its equator.

The most important property of the magnet, is its polarity; by which, the mariner can steer his ship over the pathless ocean in whatever direction he pleases; whereas, before the discovery of it was made, navigators had no other guide than the stars, when they could not see coasts, head-lands, and promontories, and could therefore never venture far from shore. By this property of the magnet also, the miner is enabled to direct his course of labour in the depths of the earth, and the traveller to find his way through the immense forest, and over the widely extending sandy desert.

A bar of iron, by standing a long time in a particular position, or by being well hammered, may be made to acquire magnetism from the earth.

To the magnetic apparatus, belong magnets, magnetic needles, the compass, and the dipping needle.

Magnets are either natural or artificial. The natural magnet is cut into various forms according to the uses for which it is required. Their most common shape is oblong, with the poles at the two most distant extremities. Some have been made of a spherical form, so as to resemble the terrestrial globe. Magnets of this kind are called terrellæ, or little earths, and upon their surface the magnetic poles, and meridian and equator are usually drawn.

Natural magnets of an oblong shape generally have a piece of soft iron attached to each of their poles. This is called the conductor. Another piece of soft iron is placed so as to join the two extremities of the conductors, and is furnished with a hook or hole in the middle.

These, together, are called the armature of the magnet.

The artificial magnet is sometimes made of an oblong form, and sometimes in the form of a horse-shoe, the two poles being brought near to each other; and at other times it is semi-circular.

The magnetic needle is an oblong, narrow piece of steel, tempered so as commonly to have the blue tinge upon it, which is seen in watch-springs. It is supported upon a brass point in a horizontal position; but so balanced, as to be left at full liberty to arrange itself in the magnetic meridian. In order to be properly balanced upon its pivot, a hollow cap, formed of some substance not attractable by the magnet, is placed near the centre. This cap is usually made of brass, but for nice experiments, of agate, because it is less liable to wear, and consequently the needle will retain longer its original suspension.

THE COMPASS.

The principle upon which the compass is constructed, is extremely simple. A magnetic needle is suspended upon a pivot, so as to move freely in the centre of a circular card, on which are marked the four cardinal points, north, east, south, west, with all the intervening points from which the winds may blow, divided into quadrants. Then, as the magnetic needle constantly turns towards the north and south, all other directions may thence be determined. This may be called the common pocket or land compass.

The mariner's steering compass consists of a circular brass box, containing a card marked with the thirty-two points from which the winds may blow, fixed on a magnetic needle. The needle, together with the card, turns on an upright pin fixed in the middle of the box. In the centre of the needle, is a brass conical socket or cap, whereby the card, hanging on the pin, turns freely round the centre. The top of the box is covered with glass, that the motion of the card may not be disturbed by the wind. The whole is enclosed in another box of wood, where it is suspended by brass hoops, named gimbals, to preserve the card in a horizontal position.

The azimuth compass is a steering compass to which are adapted two sights, through which the sun is to be seen, in order to find its amplitude, or its azimuth; whence the declination of the magnetic needle from the true meridian may be determined.

The variation compass is an instrument made to show the daily variation of the magnetic needle upon land. It is generally much longer than the sea compass, and the box is commonly of an oblong form.

The dipping needle is an oblong bar of steel balanced between two horizontal slips of brass, so as when magnetised, to form an angle with the horizon, equal to the dipping of the needle at the place where the instrument is made. The two horizontal slips of brass are either fixed to a graduated semi-circle which is supported on a wooden stand, or form diameters to a brass ring, which is graduated on its circumference, and furnished with a ring by which it may be held on the finger.

The attraction between a ferruginous body and a magnet, is mutual.

Magnetic attraction is not sensibly impeded by the interposition of bodies of any kind that do not contain iron in their composition.

The attractive power of the magnet is increased by the near approach of a piece of iron.

The attractive power of a magnet is augmented by increasing the weight suspended to it.

The contrary poles of magnets attract each other.

The corresponding poles of magnets repel each other.

Iron, or steel, is rendered magnetical by being placed in a position corresponding to the magnetic meridian.

A bar of iron long hammered, or exposed to violent friction, while lying in the magnetic meridian, becomes magnetic.

Magnetism may be induced on substances capable of receiving it, by heat.

Various opinions have been entertained concerning this wonderful power, called magnetism. Some philosophers ascribe the direction of the magnetic needle, to vast magnetic rocks, situated in the inaccessible polar regions. Others consider the earth itself to be a great loadstone, or else, as containing a great loadstone within it. The latter opinion is thus maintained. All the appearances of natural magnetism, are similar to what would be observed in the earth, were there within it a large magnet, having its poles situated near the poles of the equator; namely, the north pole not far from Baffin's bay, in North America, and the south, in the opposite point of the globe.

Philosophers are very much divided in their opinion, concerning the situation of the magnetic poles of the earth. The observations of Captain Parry, upon the magnetic needle, during his extraordinary expedition towards the north pole, seem clearly to show, that the north magnetic pole is situated very nearly in latitude 75°. north, and west longitude 102°.

Magnetism acts on the whole surface of the globe, and even at some distance from it in the atmosphere.

The magnetic power increases from the equator to the poles. This position appears to be weakened, if not contradicted, by a fact which took place in Captain Parry's voyage. In north latitude 73°, the directive power of the needle became so weak, as to be completely overcome by the action of the ship, so that the needle actually pointed to the north pole of the ship.

Humboldt determines the magnetic equator to be in Peru about 7°. 1'. S. latitude.

Various experiments appear to prove that magnetism possesses a great analogy to Galvanism.

QUESTIONS.

What is magnetism? What are the poles of the magnet? What is the magnetic equator? What is the polarity of the magnet? What important invention is grounded upon the polarity of the magnet? What is the magnetic meridian? What is the variation, or declination of the magnet? What is the dipping of the magnetic needle? When does repulsion take place between two magnets? When does attraction take place between two magnets? What is the axis of a magnet? What are artificial magnets, and in what forms are they generally constructed? How does iron become magnetised? How many kinds of compasses are there? What is the armature of a magnet? What is the magnetic needle? What is the dipping needle? What is the mariner's compass? What is the azimuth compass? What is the variation compass? What are the chief principles of magnetism? What is supposed to be the cause of magnetism? Where are the magnetic poles supposed to be? Where is the magnetic equator according to Humboldt?

CHAP. X.

METALS.

PERFECT METALS.

The splendour and beauty of some of the metals, and the utility of others, have caused them to be valued highly, and sought after eagerly by mankind in every age.

To perfect metals belong the qualities of fusibility, or the capability of being melted; ductility, or the capableness of being drawn out into wire; and malleability, or the capability of being beaten into thin plates.

The metals which do not possess all these properties are called semi-metals.

The perfect metals are, Platina, Gold, Silver, Iron, Copper, Lead, and Tin.

Platina, or Platinum, is the heaviest of the metals. It is produced principally in the gold mines of South America. Platina resembles iron in its appearance, and possesses some of its properties, being as hard as that metal when in a state of steel, and as difficult to be melted as that is, when in the state of soft iron. It may be mixed advantageously with several of the other metals. The first specimen of this metal was brought to England in 1794.

Gold is the purest, the most malleable, and the most ductile of all the metals. A single ounce of gold can be extended so as to cover a surface of nearly 150 square feet; and the wire-drawer will, from that quantity, produce a wire a thousand feet in length, and without a flaw perceivable even by the aid of the microscope.

This metal is found in mines, and in the sands of rivers in Guinea, in Chili and Peru. It is found in small quantities in most parts of the earth.

Silver is a white metal, next to gold in ductility and value. It is found in many countries, but most abundantly in the mines of Potosi, in South America.

This metal is particularly useful, as it is not liable to be oxidated, or rusted.

Iron is the most useful of the metals, and is, at the same time, the most abundant and most universally diffused. It has a peculiar metallic brilliancy, and is of a greyish or bluish-white colour. One of the most extraordinary properties of iron is that of possessing the magnetic virtue, or of attractability by the magnet. In malleability, iron is inferior to gold or silver; but it is very ductile, for it may be drawn out into wire almost as fine as a hair. Its tenacity is wonderfully great. An iron wire only .078 of an inch in diameter, will support a weight of 500lb. avoirdupois. Yet iron is not easily fused; it becomes red long before it melts, and its different degrees of temperature produced by the heat applied to it, are distinguished by the different shades of red which it exhibits. When iron is exposed to the air, its surface soon becomes covered with a brown powder, which is called rust. This is produced by its combining with the oxygen of the atmosphere, and this process is named oxidation. Iron combines readily with carbon. When carbon combines with one-tenth of its weight of iron, it constitutes a carburet, which is found native, and is distinguished by the name of Plumbago, commonly called black lead, the substance of which black lead pencils are made. When iron is first extracted from its ores, that is, the substances in which it is found, it is called crude or cast iron.

When iron is separated from those substances which debase its properties, and prevent its application to the purposes of pure or malleable iron, it is then named wrought or soft iron.

When iron is combined with a certain portion of charcoal, and hardened by being plunged, when heated, into cold water, it becomes steel.

Steel possesses very different properties from iron. It is very hard and brittle, does not yield to the file, and retains the magnetic virtue for any length of time. The best steel is used for making the finer kinds of cutting instruments.

Tin is a metal which was known in the earliest ages. It exists naturally in three different states, is of a whitish colour, nearly as brilliant as silver, and is one of the softest of metals. It is very flexible, and produces a peculiar sound when bent or folded.

Tin is so malleable that it can be easily beaten out to the one-thousandth part of an inch. It is one of the most fusible of metals, is capable of being greatly expanded by heat, and is a good conductor of electricity.

Tin is an extremely useful metal, being applied to various purposes and conveniences of life, to the making of pots, kettles, and various domestic utensils.*

Lead is found in great abundance in many parts of the world, and in a great variety of forms and combinations. The most common form of lead is in a state of sulphuret, when it is combined with sulphur. It is of a grey, brilliant colour, and very brittle; is one of the softest of metals, and possesses considerable malleability. Lead is very fusible; it oxidates slowly.

If the oxide of lead be exposed to a strong heat in a furnace, for fifty or sixty hours, it is converted into a red powder, called minium, or red lead.

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* Great quantities of tin are found in Devonshire and Cornwall, which supply with that article the greater part of Europe. Six pounds of brass, and fifteen pounds of lead, to a hundred pounds of tin, form the useful composition called pewter.

When the oxide of lead is exposed to a very violent heat, it melts into a kind of glass. In this state it has the name of litharge.

White lead, or ceruse, is prepared by exposing thin plates of lead to the vapour of vinegar. This is a very pernicious substance. The men engaged in making it seldom live long, and frequently become paralytics. It is employed as a paint, and for various other purposes.

Lead combines with tin in all proportions, and by such combinations its hardness and density are increased. Tin foil is a combination of lead and tin, and the sheet lead used for lining the boxes in which tea is brought from China, contains a certain portion of tin.

Lead, and the numerous preparations made from it, are applied to various purposes. In the metallic state it is employed in the construction of different vessels, for water pipes, and for the covering roofs of buildings. In the state of oxide it is used as a paint, in the fabrication of enamels for porcelain and pottery, and in the preparation of coloured glass and artificial precious stones.

The greatest caution ought to be observed in the use of leaden vessels in domestic economy, because acids dissolve the lead; and the effects of it taken into the stomach, are very deleterious, frequently producing dangerous diseases, and even death.

Copper appears to have been known in the earliest ages of the world. The Egyptians, Greeks, and Romans, were well acquainted with this metal, and with many of its uses. It is found in most countries of Europe, but especially in Sweden.

Copper exists abundantly in a natural state, and is often found alloyed with other metals; combined with sulphur, in the state of oxide, and in that of salt.

Copper is a very brilliant metal, of a fine red colour, different from every other metallic substance. It is very malleable, and may be hammered out into leaves so fine, as to be wafted away by the wind. It possesses, also, a considerable degree of ductility, and its tenacity is very great. Copper excites a peculiarly astringent and disagreeable taste. When taken internally into the human frame, it is extremely mischievous, acting as a poison. It requires a red heat to melt it, and if that temperature be raised, it is sublimed in the form of visible fumes.

When copper is exposed to the air, especially to damp air, it is quickly deprived of its lustre. It assumes a dull brown colour, which gradually deepens till it is converted into the hue of antique bronze, and at last is covered with a shining green crust, called verdigris. Copper combines with almost all metals readily, by means of fusion; and many of its alloys are of great utility to the arts.

Combined with zinc, copper forms brass, which is of a fine yellow colour, less liable to tarnish than copper, and more fusible; and pinchbeck, which is less malleable than brass, but has nearly the colour of gold.*

Combined with tin, copper forms bronze for casting statues and cannons, bell metal, and metallic mirrors.

As copper, when acted upon by acids, is very hurtful to the stomach, those vessels which are made of it, for the purposes of cookery, are lined with a thin coating of tin.

Next to iron, copper is of the most extensive utility among the metals. In the metallic state it is employed in forming a great variety of instruments and utensils. Some of its oxides and salts are much used in painting, dying, and enamelling.

Its alloys, with other metals, are applied to many important purposes in the arts, and in domestic economy.

QUESTIONS.

What are the properties belonging to metals called perfect? What are those metals called which do not possess all those qualities? Which are the perfect metals? What are the properties of platina? Of gold? Of silver? Of iron? Of copper? Of lead? Of tin? What is steel?

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* Brass is made in the following manner: — Copper in thin plates, or copper reduced to grains, by being poured into water, when in a state of fusion, is mixed with calamine, the ore of zinc, and with charcoal, and then exposed for a long time, to a degree of heat not quite strong enough to melt the copper, but strong enough to evaporate the zinc. The vapours of the zinc penetrate the copper, change its colour from red to yellow, and greatly increase its weight. It is then brass.

What is brass? What is pewter? What is minium, or red lead? What is ceruse, or white lead? What is verdigris? What is bronze? What is bell metal? To what useful purposes are the respective metals applied?

CHAP. XI.

METALS—continued.

SEMI-METALS.

THE imperfect or semi-metals are, Mercury, Zinc, Nickel, Antimony, Arsenic, Bismuth, Cobalt, Manganese, Palladium, Rhodium, Iridium, Osmium, Tellurium, Chromium, Molybdenum, Uranium, Tangsten, Titanium, Columbium, Cerium; to which may be added Potassium and Sodium, found by Sir H. Davy to be the basis of Potass and Soda.

It appears that mercury was known in very early ages. From its resemblance to silver, and from its being in the fluid state, it received the name of quicksilver. Native, or virgin mercury is found in the cavities or clefts of rocks, and in strata of clay, or of chalk, in the form of liquid globules. It is more frequently met with, alloyed with other metals, or, as it is then called, amalgated; most often with silver.

The red sulphuret, known by the name of cinnabar, is commonly its accompanying ore. Sometimes it effloresces on the surface of the ore, and it is then called flowers of cinnabar, or native vermilion.

The colour of mercury approaches to white

It is one of the most brilliant and heavy of the metals; and, when not tarnished, it makes a good mirror. It has no perceptible taste or smell.

At the ordinary temperament of the atmosphere, mercury is always fluid, but when exposed to a certain degree of cold it becomes solid.

When exposed to a certain degree of heat, mercury boils, and is converted into an invisible and elastic vapour.

Mercury is a very useful metal. In the metallic fluid state, it is applied to the construction of meteorological instruments; such as the thermometer and barometer. It is likewise employed for various purposes, in the arts; in gilding; in forming an amalgam, with tin, for covering the backs of mirrors; for separating gold and silver from their ores. It is of considerable importance in chemistry; and many preparations from it, are some of the most efficacious remedies in different diseases of the human frame.*

ZINC.

It is supposed that the Greeks were acquainted with this metal, and that in combination with copper, it formed the famous Corinthian brass.

Zinc is of a brilliant white colour, with a bluish shade in it. It is brittle, yet possesses some low degree of malleability; for by gradual and cautious pressure it may be formed into thin plates. It has a slight odour, and a peculiar taste, which is communicated to animal substances when rubbed against it. The ore in which it is generally found, is called calamine. Zinc is fusible, and evaporable, by strong heat. Zinc is employed in many of the arts. It forms useful alloys with some of the other metals. It is applied also to medicinal purposes. The sulphate of zinc is sometimes given as an emetic, and is frequently used in solution, as an eye-water. The oxide of zinc, or the flowers of zinc, have been prescribed as an antispasmodic, and especially in cases of epilepsy.

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* Mercury is chiefly found in Hungary, Spain, Italy and Peru.

Great Britain is supplied with this metal principally from Friuli in Italy.

ARSENIC.

It appears that this metal has been long known in its state of combination with sulphur, when it is a reddish mineral, and that it was employed by the ancients in painting. Arsenic is frequently found native, in dark coloured masses, which have little brilliancy, and exhibit no metallic lustre, excepting at their fractures, when they are broken. It is sometimes seen combined with other metals; as with iron, when it is called arsenical pyrites, and with sulphur, when it is of a yellow colour and well known under the name of orpiment. In whatever state arsenic is found, it may easily be detected, for being thrown on burning coals, a white fume rises, and a smell like that of garlic is exhaled. Arsenic is extremely brittle, and the most volatile of all metals. When heated in contact with air, it burns with a blue flame, and is sublimed in the form of a white, acrid, soluble mass, which is called the white oxide of arsenic, or, white arsenic. By this latter name, it is well known as a most violent poison, corroding and destroying the coats of the stomach, and other organs of animals. In this state of white oxide, arsenic is much employed in the arts, and is sometimes given as an internal remedy in the diseases of cancer and intermitting fever.

To counteract the effects of arsenic, when it has been taken into the stomach, one of the most efficacious remedies, is water impregnated with sulphurated hydrogen gas, or with some of the alkaline sulphurets.

COBALT.

The mineral called cobalt or cobolt, was employed to colour glass, first about the middle of the sixteenth century; but was not distinguished as a peculiar metal till 1732. The metal is never found in a state of purity, but alloyed and mixed with arsenic or other metals. Cobalt is of a grey colour, inclining to red; very brittle and easily reduced to a fine powder; grey, and of little brilliancy. It is one of the most infusible of metals.

Cobalt, in its metallic state, is scarcely ever employed. Its oxides are used for enamelling, for colouring porcelain, and a preparation of it called smalt or smelt, is well known as communicating a bluish tinge to linen when washed.

MANGANESE.

This substance has been long employed by glass makers, on account of its property of depriving glass of its colour, and is called glassmaker's soap.

In its metallic state, manganese is of a greyish white colour, of considerable brilliancy, and of a granular texture. Its hardness is equal to that of iron. It is very brittle, and very difficult to be melted. When in the state of powder, it is often attracted by the magnet, from which it is very hard to separate it. From the black oxide of manganese, chemists most commonly procure the oxigen gas, of which they have need; for which purpose it is usually exposed to a red heat, in an iron vessel.

BISMUTH.

This metal was known to the ancients, but was considered by them as a variety of some other metal, rather than as a metal in itself. Hence it was distinguished by the names of green tin, grey lead, white antimony. In its metallic state, bismuth is white inclining to yellow, exhibiting a texture composed of large brilliant plates. It possesses considerable hardness; is very fusible, has very little elasticity and no ductility; and crystallizes more easily and more readily than any other known metal. Bismuth is applied to many uses. It forms some important alloys with softer metals, communicating to them hardness and consistency. Its oxides are employed for the preparation of yellow enamels, and in the fabrication of coloured glasses, to give a greenish yellow tint.

ANTIMONY.

This was not known as a peculiar metal till near the close of the 15th century. In a state of purity, antimony is of a brilliant white colour, much resembling that of silver or tin. It has a very perceptible taste and smell, particularly if it be rubbed for some time with the hand; and is extremely brittle, so as to be easily reduced to a fine powder. Antimony undergoes no change by being exposed to the air. Antimony is used for various medicinal purposes, and will continue to communicate its properties to wine, or other liquids for a length of years without being exhausted. A basin or small goblet made of this substance, has been known to do this; rendering wine antimonial, for a long series of years, without apparently losing any of its bulk, or experiencing any diminution of its qualities.

This mineral is said to owe its name antimony, anti monachos, antimoine, to the extraordinary circumstance of its imprudent application having poisoned a number of monks of a certain convent in Germany. When water comes in contact with antimony made red hot, it is suddenly decomposed; which decomposition is accompanied with a violent detonation or explosion, and a very brilliant white flame.

Antimony is not only used in various medicinal preparations, but also as an alloy with other metals; and in the state of oxide, it is employed in the fabrication of coloured glass; in enamels for pottery and porcelain, and in forming different shades of brown, orange, and yellow colours.

By various methods, some of the metals are employed for producing different colours.

Iron, dissolved in stale small beer, gives the beautiful yellow, and different shades of buff colour, used in printing linens and cottons.

Copper, melted with zinc, produces a gold colour: dissolved in aqua fortis, it affords a beautiful green; dissolved in any alkali, it makes a fine blue.

Tin, when melted together with antimony and nitre, gives a light blue colour.

Lead, corroded by the fumes of vinegar, produces the fine white ceruss; burnt in a strong fire, it becomes red lead, or minium; and melted into a glass with sand, is of the hyacinth colour.

Silver, when dissolved in aqua fortis, becomes, by adding chalk to the solution, of a beautiful purple or amethyst colour.

Mercury mingled with sulphur forms a black mass, which by sublimation, affords the fine red pigment, called cinnabar, or vermilion.

Gold, dissolved in aqua regia, affords a fine yellow liquor, which imparts to animal substances a lively purple.*

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* From chromium is prepared a brilliant yellow, extensively applied to the painting of carriages, &c. It is very durable, and bears well the inclemencies of weather.

QUESTIONS.

Which are the imperfect, or semi metals? What is mercury, and what are its principal properties and uses? Where is mercury chiefly found? What are the properties and uses of zinc? Was it known to the ancients, and of what famous metal was it a constituent part? What is arsenic, and what are its properties and uses? What is the white oxide of arsenic? What are the uses and properties of cobalt? What are the properties and uses of manganese? What was bismuth formerly called, and what are its properties and uses? When was antimony first known as a peculiar metal? To what purposes is antimony applied, and what are its properties? To what circumstances does antimony owe its name? What colours does iron produce? What colours are drawn from copper? What colours does tin afford? What colours does lead give? What colours does silver afford? What colours does mercury yield? From gold, what colours are produced?

CHAP. XII.

GEMS.

Gems, or precious stones, are substances comprehended in the class of earths. Silex, Alumine, and Carbon, form the basis of most of those gems which are highly valued, rather on account of their beauty and scarceness, than of their real utility to man. By the slow and regular operation of nature during the lapse of ages, those earths are dissolved by water, and gradually deposited by their solvent in the process of crystallization. The regular arrangement of their particles, during their re-union in a solid mass, gives them that splendour and transparency for which they are so much admired, and renders them in appearance so totally different from their rude primitive ingredients. The scarcity of these beautiful crystals indicates that their formation is not effected by an easy or a quick process. The arrangement of their particles, during crystallisation, is such as to occasion transparency by affording free passage to light, and to give their agreeable colours by reflecting some of the coloured rays, and transmitting others. But their colours are partly owing, likewise, to a mixture of some metallic matter. Of those precious stones, the diamond ranks first, as being the hardest substance in nature, and its rarest production. It is pure carbon crystallised. It is combustible, and may be entirely consumed by violent heat. Diamonds are principally found in Golconda, a region of Hindûstan, in the island of Borneo, and in Brazil, in South America. They are usually discovered in an ochreous yellow earth, under rocks of gritstone; and sometimes in streams, which have swept them from their secret beds. They have no brilliancy when first raised from the earth, but are covered with a kind of earthy crust. They are of various figures; and are cut or ground into different forms after they are brought to Europe, by means of their own dust, mingled with olive oil.

Diamonds are more or less valuable according to what is called their water. Those which are most pure, transparent, and without speck or flaw, are called diamonds of the first water;

those of less brilliancy, are said to be of the second or third water, and so on, down to those that are coloured; for there are diamonds of various colours, though slightly tinged. Some are of a rose colour, some green, blue, brown, black, or marked with black spots. The usual mode of calculating the value of diamonds, is by squaring the number of carats, and then multiplying the amount by the value of a single carat. Thus, supposing one carat to be worth 2*l.* a diamond of eight carats is worth 128*l.* being 8 × 8 × 2. A carat is four grains. Polished diamonds, without blemish, are valued at six pounds the carat.

The Ruby, next in value to the diamond, is of a bright red colour. Rubies are produced in Brazil, and in many parts of the East Indies. A mountain, named Capelan, in Pegu, is remarkable for an abundance of these crystals. The rubies are generally discovered in the sands of rivers, or in clayey earth.

The Sapphire ranks next to the ruby. It is generally of a transparent blue colour. When rubbed, it becomes electric. Sapphires are found in Siberia, Bohemia, and Alsace.

The Topaz is a precious stone of a pale yellow colour. The best kind is the oriental topaz, found in Pegu, Ceylon, and Arabia. A fine variety of the topaz is met with in Brazil, of a reddish orange colour, and of uncommon brilliance.

The Emerald is of a beautiful green colour. The finest emeralds are produced in Peru, but they are found likewise in many other countries.

The Garnet varies more than any other gem in its form and colour. Some of the garnets are of deep red, some yellowish, others purple, or blackish.

The oriental garnet, of a brilliant red and free from defect, is called Carbuncle. Garnets are found in almost every country where primitive rocks exist, and are generally of a spherical form.

The Opal is a stone much esteemed for the delicacy of its colours; purple, green, red, blue, blended together, frequently in the most beautiful manner. The opal is found in veins, scattered among the rocks of Saxony, Bohemia, Arabia, and many other regions of the earth. Opals have not, however, the hardness and brilliance of the other precious stones.

The Hydrophanes is a curious stone, which, after having been immersed in water for some hours, passes from an opaque to a transparent state. When the hydrophanes is thrown into water, it emits a disagreeable odour, and numerous air bubbles arise from it, of yellow, red, or mother-of-pearl tints. When taken out of the water, it gradually loses its yellow transparency, and sinks back to its former duskiness.

The Amethyst is of a bright purple colour; the Hyacinth, deep red; the Beryl, sea green.

Agates are flints variegated with different colours, and semi-transparent. The Onyx, of a greyish hue; the Cornelian frequently cut and polished for seals and other ornaments; the Chalcedony and the Sardonix are only varieties of agate, which depend on the beauty of their colours for their celebrity. Some of the agates are marked with ramifications of brown or black, resembling those of trees: they are called arborescent agates. When these ramifications are very fine and numerous, the agates are called Dendrites.

Agates form an article of considerable commerce in Germany, where they are formed into boxes, handles for knives, and all sorts of trinkets.

Lapis-lazuli, is a stone marked with spots of gold upon a ground of deep blue.

QUESTIONS.

What are gems, and of what do the bases of most of them consist? How is their formation to be accounted for? What is the diamond; where is it found, and what are its properties? What is the ruby; where is it found? The sapphire? The topaz? The emerald? The garnet? The opal? What is the hydrophanes? The amethyst? The hyacynth? The beryl? Agates and their kinds? Lapis-lazuli?

CHAP. XIII.

MINES.

MINING.—METALLURGY.

A MINE is a deep opening under ground, whence various kinds of minerals are digged out. But the term is more particularly applied to those openings which are made to seek for metals; and though the word mining may be considered as signifying all works carried on beneath the surface of the earth, yet it principally belongs to such as have for their object the discovery and raising of the metallic ores.

The internal parts of the earth, as far as human skill and industry have ascertained as yet, consist, not of one uniform substance, but of various strata, or beds of substances, differing greatly in their appearances, in their specific gravities, in chemical qualities, in depth and solidity. In these strata are found innumerable cracks and fissures, called lodes. These are the veins of minerals or metals. The insides of these fissures are commonly coated with a hard, crystalline, earthy substance, called the walls of the lode; so that the metallic ore lies in a bed, or channel, bounded by two parallel walls of stone. To find these lodes, and to extract the ore from them, is the business of mining.

The construction of the works for this purpose, must differ according to the position of the lodes. Thus some mines are formed by a level opening, or drift, entering the base of a hill and extending to the lodes of metallic ore which may be situated within it, and which are conveyed out through that opening; and in that case, vertical openings, called shafts, are necessary only for the sake of ventilation.

But the metallic veins are most frequently situated at great depths in the earth, below the level of the sea; and then perpendicular openings, or shafts, form the means of communication from the surface to levels driven upon the lode, or vein, at various and successive depths, so as to search all parts of it, for the discovery of its contents.

This kind of mine is a wonderful display of the art and industry of mankind. It consists of the shaft, or opening, sunk perpendicularly, and various streets or galleries, running horizontally, or obliquely, according as the metallic veins are found to lie and extend. These sometimes stretch an astonishing way under ground, even under the very bed of the sea. The earth and other loose substances on the roofs and sides of these galleries, are supported by strong timbers, skilfully disposed. The waters which lodge, or flow, in these deep recesses, are pumped up by means of that most useful machine, the steam-engine. Curious mechanical contrivances are made for raising the ore when dug out from the lode, and for conveying into the different parts of the mines whatever implements and utensils are requisite for their work.

In Devonshire and Cornwall, are numerous mines of copper and tin; some of which are very extensive, and very deep.

Diamond mines are found in Brazil, and in Golconda in Hindûstan. They are principally met with in rocky soils and mountainous countries. The ore of diamonds is of a reddish or yellowish colour, and often adheres so closely to them, that their separation is effected with difficulty. The earthy and other substances dug out from the mine, are carefully washed in a kind of cistern, and the residuum, or what remains after the water is poured out from it, is examined in bright sun-shine, when the diamonds, reflecting the beams, are easily discovered. Gold and silver mines abound chiefly in Peru, in La Plata, and Mexico. The most productive mine of silver is in Potosi, a southern province of Peru. At Konigsburg, in Norway, is a very valuable silver mine, of the amazing depth of 1080 feet. Gold mines are found likewise in the Carpathian mountains, and in Transylvania.

The principal mines of quicksilver are in Idria, belonging to Austria. The shaft of the largest of those mines is 840 feet deep, and its galleries are so extensive that it takes many hours to traverse them.

The richest iron mine known, is that of Danmora, in Sweden; and in Dalecarlia, a province of that kingdom, are mines of the purest copper, one of which is 1200 feet deep. Copper mines are found also in Ireland; and in the isle of Anglesea, is a mountain named Parys, the internal parts of which appear to consist almost entirely of copper.

The most extensive coal mines are near Whitehaven, in Cumberland: some of them are 780 feet in depth, and extend under the sea in various parts.

The most abundant mines of rock-salt are those of Wielicza, near Cracow, of the Tyrol, of Castille and Cordova in Spain, of Saltzburg in Germany, and of Cheshire in England. The great mine at Wielicza is 6000 feet long, 2000 feet broad, and 800 deep. It is a kind of subterraneous country, inhabited by numerous families, having their own laws and customs, their public roads, horses, and carriages; chapels, and huge pillars of rock-salt, which support the rocky roofs.

METALLURGY.

Metallurgy, in the general sense of the term, comprehends the whole art of working metals from the state of ores to the useful utensils which are fabricated of them. To metallurgy, in this view of it, belong the various operations of assaying, smelting, refining, parting, smithery, gilding.

Assaying is a kind of analysis or examination applied to metallic ores, or to alloys, to ascertain the quantity and proportion of only one of the ingredients of the mass.

This operation is conducted in different ways, according to the different metallic mixtures which may be its objects.

The assay of gold, silver, or platina, which are called the noble metals, because they are not oxydated, or rusted, by exposure to the atmospheric air, is commonly conducted by a process named cupellation. The alloyed noble metal, mixed with a considerable portion of lead, is exposed to a melting heat, with access of air; and thus the lead, with whatever other base metal may be in the mass, is converted to an oxide, and the noble metal is left behind, perfectly pure.

Smelting, is the melting of metals from their ores, in order that the metallic parts may be separated from the sulphur, arsenic, and earthy substances of all kinds with which they may be combined. When applied to the more precious metals, this process is called refining.

In order to facilitate the separation of metallic substances from the ores and minerals containing them, some operations are requisite, previous to melting them. The ores are washed with water; they are pounded into small masses; they are roasted or calcinated, in order to expel the volatile or noxious substances, such as water, vitriolic acid, sulphur, and arsenic.

Smithery, is the art of the smith, by which iron is fashioned into any shape, by means of fire, of hammering, of file, or any other process.

Gilding, is the art of covering certain substances with gold, either in leaf, in powder, or in amalgam with quicksilver. This art was certainly known to the ancients. After the taking of Carthage, the Romans gilded the cielings of their temples and palaces. The Capitol was the first edifice so ornamented by them. But the moderns have carried gilding to great perfection. For this purpose, the gilders make use of gold beaten out into leaves, some of which are so fine, that a thousand of them do not weigh above four or five drachms. The discovery of painting in oil, furnishes the means of gilding in such a manner as to resist the influences of time and weather.

The chief kinds of gilding are, gilding in oil, for which linseed oil is commonly used; gilding on a water size, or burnishing, which is generally used for picture-frames, mouldings, stucco, and such wooden works as will not be exposed to the inclemencies of the weather; gilding by fire, which is peculiar to metals. The gilding of metals may be effected by applying gold leaves to the surface of the metal, previously well cleaned and heated to a certain degree, and rubbing them in with a polished blood-stone, by which they are made to adhere quite close and well. In this manner, silver leaf is fixed and burnished upon brass, in making French plate. Gilding on leather, is called lacquering.

Parting, in the art of refining metals, is a process by which gold is separated from silver. The most effectual way of separating gold from silver, is to dissolve the thin plates of alloy in nitro-muriatic acid. The silver will then be found at the bottom of the vessel in the form of muriat, while the gold remains in solution, and may be precipitated by sulphat of iron. The silver may be obtained by heating the muriat with soda, in a crucible. The muriat of soda sublimes, and the silver is left pure.

QUESTIONS.

What is mining? What is a mine? What are lodes? What is the shaft; and what are the galleries of a mine? How are the waters drained from mines? Where are the most extensive and the deepest mines? What is metallurgy? What is assaying? Smelting? Cupellation? Refining? What operations are required previous to smelting? What is smithery? What is gilding? What are the various kinds of gilding? Was gilding known in ancient times? How is the gilding of metals performed? What is the process called parting?

CHAP. XIV.

CHEMISTRY.

ELEMENTARY PRINCIPLES. — AFFINITY. — ATTRACTION. — PRECIPITATION.

THAT science which investigates the elementary parts of bodies, their properties, and their action upon one another, and which teaches how to form new compounds, is called chemistry.

This term is considered by some as composed of two Greek words, *chumos,* juice, and *kuoo* to melt; and is thence spelt chemistry; but by most, it is regarded as derived from an oriental word, *kema,* signifying *black,* and thence spelt chemistry.

Chemistry is subservient to a vast variety of useful purposes in society. The arts of glass-making, of tanning, bleaching, dyeing, and metallurgy depend entirely upon chemistry.

The growth and nourishment of vegetables, the manuring of lands, pharmacy, the composition of medicines, and culinary processes, or the preparation of human food, are all objects of its enquiry.

In the infancy of chemistry, the wonders which that science unfolded to view, produced the absurd imagination, that it was possible to make a composition capable of changing all metals into gold, and of continuing human life for ever. This ideal composition was called the philosopher's stone. In the search after this, numbers were ruined; and artful impostors, who named themselves Alchemists, that is, *the chemists,* to express their superiority to common chemists, stripped the credulous of their wealth, under the pretence of teaching them the grand secret, the preparation of this wonder-working substance.

Were every individual substance submitted to chemical examination composed of different materials, the labour of the chemist would indeed be endless. But this is not the case, for the greater part of natural bodies are composed of certain principles common to most of them, though variously combined, and those principles are not very numerous. Elementary bodies are those which have never been decomposed; that is, separated into component parts, or other substances.

Fire, air, earth, and water, are all capable of being decomposed, and therefore are not primitive elements.

Division of any body is the separating of it into equal or unequal portions; while decomposition of any body is the separating from one another the various elementary principles of which it is composed. These elementary principles are called constituent parts of bodies; and as they themselves cannot be decomposed, they are also named simple bodies; while such as consist of more than one of those elements, are termed compound bodies.

Excepting electricity, heat, and light, the most general simple or elementary body, appears to be metal.

The simple or elementary bodies, which are objects of chemistry are,

1. Heat or caloric, light, and electricity. These are called imponderable, or not to be weighed, because human art has not yet discovered any means of detaining them, so as to ascertain their specific gravities.

2. Oxygen, Chlorine, Lodine, Gasses, or Airs,

which are capable of uniting with inflammable bodies, and, generally, of producing their combustion.

3. Bodies capable of uniting with Oxygen, and forming with it various compounds. Of these there are so many that it has been found convenient to arrange them in five divisions.

1. Hydrogen, a gas which, combined with Oxygen, forms water.

2. Bodies which, combined with Oxygen, form acids.

Nitrogen, a gas,	forming	Nitric Acid.
Sulphur,	——	Sulphuric Acid.
Phosphorus,	——	Phosphoric Acid.
Carbon,	——	Carbonic Acid.
Boracium,	——	Boracic Acid.
Fluorium,	——	Fluoric Acid.
Muriatium,	——	Muriatic Acid.

3. Metallic Bodies, forming Alkalies.

Potassium,	forming	Potash.
Sodium,	——	Soda.
Ammonium,	——	Ammonia.
Lithium,	——	Lithina.

4. Metallic Bodies, forming Earths.

Calcium, or metal	forming	Lime.
Magnium,	——	Magnesia.
Barium,	——	Barytes.
Strontium,	——	Strontites.
Silicium,	——	Silex.
Alumium,	——	Alumine.
Yttrium,	——	Yttria.
Glucium,	——	Glucina.
Zirconium,	——	Zirconia.

5. Metals either naturally metallic, or yielding their oxygen to Carbon, or to heat alone.

MALLEABLE METALS.

Gold, Platina, Palladium, Silver, Mercury, Tin, Copper, Iron, Lead, Nickel, Zinc, Cadmium.

BRITTLE METALS.

Arsenic, Bismuth, Antimony, Manganese, Tellurium, Cobalt, Tungsten, Molybdenum, Titanium, Chromeium, Uranium, Columbium, Iridium, Osmium, Rhodium, Cerium.

Chemical attraction, or the attraction of composition, is the peculiar tendency that bodies of a different nature have to unite with each other. By this agent, all compositions and decompositions are effected. This differs from the attraction of cohesion, inasmuch as the latter exists only between particles of the same nature; whereas chemical attraction takes place between particles of a dissimilar nature. Thus the attraction of cohesion unites the integrant portions of bodies, and the attraction of composition combines their constituent particles.

Example.—If nitric acid be added to copper, every particle of the copper will combine with a particle of the acid, and, together, the two substances will form a new body, totally different from the copper, or the acid. Thus by the action of the nitric acid, the copper is reduced into minuter parts than it could have been divided into by any mechanical force.

This chemical attraction is sometimes called affinity. It is the disposition which elementary particles show, to unite with some bodies in preference to others.

If to a body composed of two principles, a third principle be added, which has a greater affinity for one of them, than the two original principles have for each other, that body will be decomposed; that is, its two constituent principles will be separated by the influence of the third principle added.

Example.—If to the composition formed by the combining of the copper and the nitric acid, a piece of iron be presented, the acid, having a stronger affinity with the iron than with the copper, will quit the copper, and will combine with the iron. The copper will then sink to the bottom of the mixture, and appear in its simple form. This operation the chemists call precipitation. In this case the copper is said to be precipitated.

Example.—If the blade of a knife be dipped into the fluid formed of the nitric acid and the copper, instead of being wetted with a blueish liquid, the colour of the mixture, the iron of the knife will be covered with a thin coat of copper. The nitric acid, quitting the copper, combines with the iron, and, by that action, precipitates the copper upon the iron.

This chemical attraction, or affinity, may be, like the attraction of cohesion, and of gravitation, one of the powers inherent in matter, for which our limited faculties can account only by attributing them to the immediate agency of the universally present Creator. The illustrious chemist, Sir H. Davy, has, however, suggested a solution of the difficulty. He supposes that all bodies are united with one or other of the two kinds of electricity, called positive and negative; and that those bodies, which are in union with opposite electricities, are disposed to combine, being impelled towards one another, by the attraction which the opposite kinds of electricity have for each other.

QUESTIONS.

What is chemistry, and whence is that name derived? To what purposes is chemistry subservient? What were alchemists, and the philosopher's stone? What are elementary principles? Are fire, earth, air, and water elementary principles? What is the difference between the decomposition and the division of bodies? What are simple, and what are compound bodies? What appears to be the most general elementary body, after heat, light, and electricity? What are the simple elementary bodies which are objects of chemistry? What is chemical attraction or affinity? What is the example? What is the example of the decomposition of a compound body? What is precipitation? The example. How does Sir H. Davy endeavour to explain chemical affinity?

CHAP. XV.

CHEMISTRY— Continued.

LIGHT.—CALORIC.— PYROMETER.—PHOSPHORESCENCE. —IGNITION.

Light has been considered by most naturalists to be a real substance, projected in right lines, with astonishing velocity, from the sun principally, and from all luminous bodies. But as light cannot be so confined as to be examined and weighed, the influence it has on other bodies, rather than its own essential nature, is the proper subject of chemical investigation.

Light and heat generally accompany each other, yet they may be separated. Dr. Herschel proved this by means of the prism. He found that heat is less refrangible than light; for in separating the differently coloured rays of light by that instrument, he observed that the greatest heat was beyond the spectrum, at a little distance from the red rays, which are the least refrangible. Thus it appears that the coloured rays, which are the least refrangible, retain the greatest quantity of heat.

Certain substances are capable of imbibing, of retaining for some time, and then of emitting light. This capability has been called phosphorescence. Bodies which have this property, after having been exposed to the rays of the sun, appear luminous in the dark. They give out the rays which they have imbibed from the sun, when being withdrawn from the action of that great luminary, they cease to receive his beams. The shells of shell-fish, the bones of land animals, marble, lime-stone, rotten wood, and many other substances, are more or less phosphorescent. Some animals possess this property, as the glow-worm, the fire-fly, and others. Light possesses many chemical influences. Deprived of light, men and vegetables grow pale and sickly.

Light destroys colours in various substances, as linens, silks, and others.

Heat or caloric exists in various states or modifications, which may be conveniently reduced to two general forms:—

Free, or Radiant Caloric.—Combined; or Latent Caloric.

The first of these comprehends all heat which is perceptible by the senses, and which affects the thermometer. Such are the heat of the sun, of fire, of all bodies in a state of combustion, and the warmth of animal bodies. Caloric dilates bodies, making them occupy a greater space than they did before, and thus acts directly contrary to the attraction of cohesion, by separating particles. When the attraction of cohesion is overcome by the insinuation of caloric between the particles of any body, that body is changed from a solid to a fluid.

Example.—The melting of metals or other solids. The fluidity of mercury in the general temperature of our atmosphere. When caloric is applied to a liquid, it penetrates between the particles of the fluid substance, and forces them so far asunder, that their attraction for one another is wholly destroyed, and the liquid becomes vapour, or is evaporated.

Example.—This takes place when, by the application of heat, water is made to boil and pass off in steam or vapour, and when any other body assumes an aëriform state.

All elastic fluids are called aëriform solids, and are of various degrees of density, from that of gold to that of thin jelly. Liquids have various degrees of consistence, from that of melted metals, or melted glue, to that of ether, the lightest of all known liquids.

Each individual body also admits of different degrees of consistence, without changing its state.

Example. — A piece of iron, when heated red, will not, in that state, go into a ring or frame, which it exactly fitted before, so much will its dimensions be increased by the caloric which has penetrated its substance; but when completely cooled, it will again fit the ring or frame made to receive it.

A machine has been invented, called a pyrometer, or heat measurer, which indicates accurately the dilatations of any solid body by heat.

At one end of an oblong frame rises a perpendicular pillar, with a socket at its summit to receive and hold immoveable a bar of iron, or other solid substance, whose other extremity is made to press firmly against some wheel-work at the other end of the frame, which, placed beneath a graduated dial-plate, moves its index as it is itself moved.

The bar of iron thus situated, with one end retained fast in the socket on the pillar, and the other resting against the wheel-work under the dial-plate, is heated by lamps put under it; and when it begins to dilate, presses against the wheel-work, and sets in motion the index, which points out the degrees of dilatation on the dial-plate.

The different degrees of dilatation by heat are still more discernible in fluids.

The degree of caloric communicated from the human hand dilates spirits of wine so greatly as to make the fluid ascend from a bulb into a tube communicating with it. Water is far less dilatable.

Upon this principle thermometers are constructed.

Free caloric always tends to diffuse itself equally; for when two bodies are of different temperature, the warmer of the two gradually imparts heat to the colder, till both be brought to the same temperature.

Caloric appears to be universally present in all substances; for no body is known in which some degree of it is not discoverable.

Some substances are better conductors of caloric than others.

Caloric more easily finds a passage through marble and wood than through leather and wool, and therefore a marble slab, or a wooden table, will seem colder to the touch than a carpet, or the cover of a book, though the thermometer applied to them may prove that all those objects are of the same temperature.

Many animal substances are bad conductors of heat, and thus fur, wool, hair, skin, feathers. and down, are given, by the gracious Lord of Providence, to various animals as preservatives against the cold of winter; and the warmest dress of man is made of such materials.

Transparent substances are not heated by the passage of the sun's rays through them. Thus the atmospheric air, when perfectly pure, transmits the beams of the sun without being heated by them. If glass be quite transparent it does not imbibe caloric from the rays of the sun passing through it.

Example. — A burning glass, while by converging the sun-beams to a focus, it fires combustible bodies, has not its own temperature raised.

The air of our atmosphere is warmed, not by imbibing caloric from the sun's rays in their passage through it, but by the reflection or radiation of heat from the earth. This accounts for the fact of the air on high mountains being colder than the air of the valleys, though the former be nearer to the sun than the latter.

Solution takes place when any body is melted in a fluid. In this operation the body is reduced to such a minute state of division by the fluid, that it becomes invisible in it, and partakes of its fluidity. But in common solutions this happens without any decomposition. The body is only divided into its integrant particles.

Example. — Melt salt in water, and it totally disappears; the water remains clear and transparent. Yet though the union of the two bodies appear so complete, it is not produced by chemical combination. The salt and the water both remain unchanged, and if they be separated by evaporating the water, the salt remains in the same state as before.

The two principal solvent fluids are water and caloric.

A mixture is, when substances dissolved in water render it thick and turbid.

Example.—Powder of chalk added to water makes it opaque and whitish, like milk.

Saturation is when the solvent can retain no more of the dissolved substance, and consequently ceases to act.

Example.—If you continue to throw salt into water, till it sink visible to the bottom, and displaces the water, the water is then incapable of dissolving any more salt, and is said to be saturated.

Caloric dissolves water, and converts it into vapour by the same process as water dissolves salt. The particles of water are so minutely divided by the caloric, as to become invisible. This shows the cause why the vapour of boiling water is invisible when it first issues from the spout of the kettle; it is then completely dissolved by the caloric. But the air with which it comes in contact being much colder than the vapour, the latter yields to it a quantity of its caloric. The particles of vapour being thus, in great measure, deprived of their solvent, gradually collect and become visible in the form of steam, which is water in a state of imperfect solution. If a cold plate or glass be held over a tea-urn, the steam issuing from it will be converted into drops of water upon the plate or glass. This is condensation.

Water, when heated to the boiling point, can no longer exist in the state of water, but is necessarily converted into vapour or steam, whatever may be the state of the surrounding atmospherical air. This is called vaporization. But the atmosphere, by means of the caloric it contains, can take up a portion of water at any temperature, and hold it in a state of solution. This is evaporation. And by this means the atmosphere is continually carrying off moisture from the earth until it be saturated.

Pressure is a great obstacle to evaporation. There are liquids that contain so large a portion of caloric, and whose particles consequently adhere so slightly together, that they may be converted into vapour merely by removing from them the pressure of the atmosphere, by which it is proved that the weight of the superincumbent air alone retains those substances from being in an aëriform state.

Example. — Ether is such a fluid; for it will boil and be changed into vapour if, by means of an air-pump, the weight of the atmospherical air be removed from it. So that here is an instance of a liquid boiling without the application of heat.

To make a liquid boil or evaporate, it is necessary to overcome two forces, the attraction of aggregation, and the pressure of the atmosphere.

Example. — It is found that on the summit of very elevated mountains much less heat is required to make water boil, than in the plain, where the weight of the atmosphere is greater.

Ignition is that emission of light which is produced in bodies when they are raised to a very high temperature, and which is the effect of accumulated caloric. This is independent of combustion. Clay, chalk, and other incombustible substances may be made red hot. When a body burns, the light emitted is the effect of a chemical change, while ignition is the effect of caloric alone, and no other change but that of temperature, is produced in the ignited body.

All solid bodies and most liquids are susceptible of ignition; that is, of being heated so as to become luminous.

The expansive force of steam is so great as to overcome almost all mechanical resistance.

QUESTIONS.

What is light supposed to be? Can light and heat be separated? What is phosphorescence? What are the two general forms in which caloric exists? What does free, or radiant caloric comprehend? What effect does caloric produce on solid bodies into which it is introduced? Examples. What effect does caloric produce on liquid bodies into which it is introduced? Examples. Do bodies admit of different degrees of consistence, without changing their state? Example. What is a pyrometer? Are the different degrees of dilatation by heat, more discernible in fluids than in solids? Example. What instruments are made upon this principle? What other peculiar tendency has free caloric? Is caloric found in most substances? What are the best conductors of caloric? What are the good effects of animal substances being bad conductors of caloric? What substances are not heated by the passage of the sun's rays through them? Examples. What is solution? Example. What are the two principal solvent fluids? What is mixture? What is saturation? Example. How does caloric convert water into vapour? What is vaporization? What is evaporation? What is the great obstacle to evaporation? Example. Give an example of a fluid that may be made to boil without the application of heat? What forces must be overcome in order to make water boil, or, evaporate? Example. What is ignition? Give examples of bodies capable of ignition? Is the expansive force of steam great?

CHAP. XVI.

CHEMISTRY — continued.

LATENT HEAT. — GAS.

THE capacity of a body for caloric, is that disposition which requires more or less caloric for raising its temperature to any degree of heat.

Different bodies. demand different quantities of caloric to elevate them to the same temperature. Example.—A pound of lead, a pound of chalk, and a pound of milk, placed in a heated oven, will gradually acquire the temperature of that oven; but the lead will attain it first, the chalk next, and the milk last.

Combined caloric is that which fills the capacity of any body, is imprisoned in it, and is not perceptible.

Caloric is felt only when it is disengaged, and in a free state.

Specific heat, or caloric, expresses the relative quantity of caloric which different species of bodies of the same weight and temperature, are capable of containing.

Latent heat, is that portion of combined caloric which is employed in changing the state of bodies; that is, in converting solids into liquids, or liquids into vapour. When such a change is effected in any body, its expansion occasions a sudden and considerable increase of capacity for heat, in consequence of which, it immediately absorbs a quantity of caloric, which becomes fixed in the body transformed; and as it is not perceptible to our senses, it is called latent heat, or latent caloric. This latent heat is capable of being extricated from bodies in which it exists.

Example.—If a few drops of sulphuric acid be poured into a phial filled with muriate of lime dissolved in water, the whole, or very nearly the whole mass, will instantaneously become a solid white substance like chalk; and the latent heat escaping, will render warm the bottle in which the action took place..

Again, when water is poured upon quick lime, the water incorporates with, and becomes solid in the lime; in consequence of which, the latent heat which kept the water in a liquid state, is set free, and escapes in a sensible form; the heat is felt. The white vapour which rises, is formed by some of the particles of lime in a state of fine dust, which are carried off by the caloric.

The atmospherical air is composed of two gasses, oxigen gas, and nitrogen, or azotic gas, with a small portion of carbonic acid gas.

The name of gas is given to any fluid capable of existing constantly in an aëriform state, under the pressure, and at the temperature of the atmosphere. The oxigen gas constitutes a little more than one-fifth of the atmospheric air, and the nitrogen gas, a little less than four-fifths, and the carbonic acid gas, about one-half a part per cent.

Oxigen gas is essential to combustion, or the action of burning, for combustion is the rapid combination of a body with oxigen, attended by the disengagement of light and heat.

Example.—So favourable is oxigen to combustion, that iron wire may be made to burn in it, with a very brilliant and beautiful flame.

Oxigen gas, in certain proportions, is necessary to sustain animal life. Oxigen gives the acid character to all mineral and vegetable salts, the bases of which are insipid till combined with oxigen.

The calcination of metals, that is, the reducing them to powder by fire, is effected by their union with oxigen. Oxigen forms a constituent part of that necessary fluid, water.

Oxigen is supposed to be the only elementary body naturally combined with negative electricity. In all the other elements, the positive electricity prevails, and consequently they have all an attraction for oxigen.

The oxigen which we inhale in the atmospheric air, carries off from the blood that matter of carbon, the excess of which would be pernicious; and by yielding caloric, which it possesses in great abundance, and which its combination with carbonic acid gas deposits in the lungs, repairs the continual loss of heat which we undergo by our communicating it to surrounding bodies of a lower temperature than our own.

To breathe pure oxigen for any considerable time, would be very injurious. So great a quantity of caloric is disengaged from it by the act of respiration, that to inhale this gas unmixed, would produce violent inflammation, and by making the heart beat too fast, would cause the blood to circulate with excessive rapidity. Oxigen gas may be obtained by means of heat from red lead, calcined mercury, nitre, and the black oxide of manganese. It may also be gained by the action of the vitriolic and nitrous acids, upon a variety of metallic and mineral substances. It may likewise be procured from green vegetables immersed under water, which, when exposed to the sun's rays, emit this gas slowly.

Nitrogen, or azotic gas, is destructive of animal life and combustion.

This gas may be procured by absorbing or destroying the oxigen with which it is united in the atmospheric air. It is always found remaining after a quantity of atmospheric air has been respired by animals, after the combustion of bodies, or putrefaction ; because, in all those cases, the oxigen with which it was combined is consumed. Various substances may be made to yield nitrogen, or azotic gas. The air bladders of fishes are full of it, and it may be collected by breaking them under glass vessels, inverted in water. Azotic gas shows no signs of acidity, nor of being capable to turn the blue colours of vegetables into red, which is the common test to prove whether any particular fluid contain an acid. It does not precipitate lime held in solution by water.

It extinguishes animal life, and combustion. Example.—If an animal, or a lighted candle be plunged into a vessel filled with this gas, the animal is immediately suffocated, and the flame stifled.

It is rendered respirable by vegetables which furnish oxigen.

It is the basis of the nitrous acid, or aquafortis.

Volatile alkali is formed from the union of nitrous gas with hydrogen. Oxigen does not always manifest itself in the form of a gas. It is a constituent part of a great number of bodies both solid and liquid. It may be absorbed also, from the atmosphere, without any sensible production of light and heat. In this case, the absorption of oxigen, is called oxigenation, or oxidation.

Most metals require to be made red hot before they are capable of attracting oxigen rapidly, in any large quantity. By this combination they lose most of their metallic properties, and fall into a kind of powder, termed an oxide; as oxide of lead, oxide of iron, oxide of manganese.

The attraction of metals for oxigen varies greatly. Some will not combine with it, but at a very high temperature, or by the assistance of acids, while others oxidate spontaneously, even at the lowest temperature. Thus manganese scarcely ever exists in the metallic state, as it absorbs oxigen immediately on being exposed to the air, and crumbles to an oxide in the course of a few hours. All metals, excepting gold, silver, and platina, imbibe oxigen from the air, though gradually. Their surface is slowly converted into an oxide, which is called rust. This rusty surface preserves the interior part of the metal from oxidation, as it prevents its contact with the atmospheric air.

Not the smallest particle of any natural substance can be absolutely destroyed or consumed.

A compound body is decomposed by combustion. Some of its constituent parts fly off in a gaseous form, while others remain in a concrete state. The former are called volatile products, the other, fixed products of combustion. But when collected, the dissevered particles always exceed the weight of the body decomposed, by that of the oxigen which has combined with them and occasioned their decomposition.

QUESTIONS.

What is the capacity of a body for caloric? Do different bodies require different quantities of caloric to raise them to the same temperature? Example. What is combined caloric? What is latent heat? Can latent heat be disengaged from bodies in which it exists? Examples. What is a gas? Of what three gasses is the atmospherical air composed, and in what proportions? What are the properties of oxigen gas? How may oxigen gas be obtained? What are the characteristics of nitrogen, or azotic gas? How may nitrogen gas be procured? What are oxides? What is rust? What are volatile and fixed products.

CHAP. XVII.

CHEMISTRY—continued.

HYDROGEN GAS. — SUBLIMATION.— SULPHURIC ACID GAS.

Hydrogen Gas was formerly called inflammable air, because it is very combustible and burns with a great flame. Its present name is derived from two Greek words, *udoor,* water, and *ginomai,* to produce. It is a constituent part of water; for that most useful fluid is composed of eighty-five parts of oxigen, combined with fifteen parts of hydrogen, in every hundred parts of it. Hydrogen gas may be obtained by the application of heat to water.

Example. — Let water pass drop by drop through a red hot gun-barrel; at the end of which, let a tube be placed so as to communicate with a vessel inverted in water. There will then be transmitted into the vessel an aeriform fluid, which is hydrogen gas.

In this process the water is decomposed, and while the hydrogen gas passes into the glass vessel, the oxigen unites with the substance of the gun-barrel, and oxidates or rusts its internal surface. This gas may be procured, also, by means of sulphuric or muriatic acid, acting upon iron, zinc, or tin. Water may be decomposed and its hydrogen disengaged by the action of the Voltaic battery.

Hydrogen gas, combined with carbonic acid gas, has long been known to miners under the name of choke damp. It generally appears in the lower part of the mine.

Hydrogen gas is very inflammable. It is the lightest of all elastic fluids, and is therefore used for the ascent of balloons.

Metals are recovered from an oxide to a metallic state when heated in a receiver filled with hydrogen gas.

Plants will grow in this gas, without diminishing its inflammability.

Hydrogen gas destroys animal life.

The flame of a candle is owing to the combustion of hydrogen gas and carbon.

A considerable quantity of hydrogen is contained in the tallow or wax, of which candles are made. This hydrogen being converted into gas by the heat of the candle, combines with the oxigen of the atmosphere, and flame and water result from this combination. An elevation of temperature, such as is produced by a lighted match or paper, is required to give the first impulse to the combustion; but afterwards it goes on of itself, because the candle finds a supply of caloric in the successive quantities of heat which results from the union of the two electricities given out by the gasses during the combustion.

The cause of the regular shape of the flame of the candle, is the regular stream of hydrogen gas, which exhales from its combustible matter. The combustion of the hydrogen gas is completed at the point where the flame terminates, and it then ceases to be hydrogen gas, as it is converted, by its combination with oxigen, into watery vapour, but in a state of such minute division as to be invisible. In order to emit the hydrogen gas, the combustible matter of the candle must be decomposed, and the wick assists in effecting this decomposition. Its combustion first melts the combustible matter, and the burning wick (by the power of capillary attraction) gradually draws up the fluid to the point where combustion takes place; for it is observable that the wick does not burn quite to the bottom.

Hydrogen gas in composition with carbon, and then called hydro-carbonat, is the gas, by the burning of which streets and manufactories are now pretty generally lighted.

In this mode of lighting, the gas, which is obtained from coal by distillation, is conveyed to the extremity of a tube, where it is kindled, and burns as long as the supply continues.

Hydrogen gas, when mixed with oxigen gas, explodes upon contact with flame, and burns fiercely. By such a composition being generated in coal-mines, it frequently happens, that coming in contact with the lighted candles or lamps which the miners necessarily use, the gas takes fire, and explosions are occasioned which destroy men and horses within its reach.

To prevent these fatal accidents, Sir H. Davy invented a lamp, justly named the safety-lamp which has already saved the lives of many; and which, from its successful use, ranks him among the greatest benefactors of society. It is framed upon this principle, that the combustion of inflammable gas cannot be propagated through small tubes.

This knowledge suggested the idea, that if a lamp were surrounded with a wire-work, or wire gauze, of a very close texture, the interstices of the gauze would act as a tube in preventing the propagation of explosions; so that this pervious metallic covering would answer the various purposes of transparency for the light, of permeability to air, and of protection against explosions. This lamp has answered the most sanguine expectations of its ingenious projector. When it is carried into such a combination of gas as will explode when it comes into contact with flame, the combustion of the gas takes place within the lamp, and is not propagated to the external air through the interstices of the metallic gauze acting as so many tubes. Thus a miner, having a safety-lamp suspended to his belt, can venture, with safety, to whatever parts of the mine his duty may require, and at the same time enjoy the light necessary for his work. The top part of the lamp is liable to become red hot, but inflammable gaseous mixtures, cannot be exploded by a red heat.

Sulphur is a very combustible substance, seldom discovered in a pure unmixed state. It is most commonly united with metals under various forms, it exists in mineral waters; and some vegetables yield it in various proportions.

Flowers of sulphur consist of common sulphur, reduced to a very fine powder, by a process called sublimation.

Sublimation is the evaporation or the volatilisation of solid substances by heat, without combustion. Lumps of sulphur are put in a receiver, called a cucurbit, which is closed by a top piece named the head. This closed vessel is placed over a sand-bath, a vessel full of sand kept heated by a furnace, so as to preserve a moderate and uniform temperature.

The sulphur quickly begins to melt, and a thick white smoke rises, which is gradually deposited within the head of the cucurbit, where it condenses against the sides in a form somewhat like that of a vegetable substance, which circumstance has given rise to the name, flowers of sulphur. The whole of this apparatus is styled an alembic.

Sulphuric acid gas is made by burning sulphur in pure oxygen gas. Sulphur is capable of combining with hydrogen gas, which can dissolve it in small portions; in which case, a chemical union of the sulphur with the hydrogen gas is produced. This compound has a peculiarly disagreeable smell, and is called sulphuretted hydrogen gas. This gas is contained in great abundance in sulphureous mineral waters, and by impregnating common water with this gas, sulphureous mineral waters are made.

QUESTIONS.

What is hydrogen gas? How may hydrogen gas be obtained? What are the properties of this gas? How does hydrogen gas act in the burning of a candle? To what purposes is this gas applied? By what instrument are its dangerous effects in mines obviated? What is sulphur? What are flowers of sulphur and how are they made? What is a cucurbit? What is a sand-bath? What is an alembic? What is sublimation? How is sulphuric acid gas produced? What is sulphuretted hydrogen gas? Into the composition of what waters does it enter?

CHAP. XVIII.

CHEMISTRY — continued.

PHOSPHORUS — CARBON.

PHOSPHORUS is a simple substance, which is never found in a pure separate state. It is extremely combustible, melts and takes fire at the temperature of one hundred degrees, and in its combustion absorbs nearly ore once and a half its own weight of oxygen. It is a yellowish transparent body, which may be obtained from the bones of animals. It takes fire so quickly, that it is proper to handle it under water, lest the heat of the fingers should inflame it. It burns with a very brilliant flame. The result of its combustion is phosphoric acid. Phosphorus imbibes light, and gives it out in the dark.

Example.—Letters, or figures of any kind, made with phosphorus, are invisible by daylight, but when darkness takes place, become visible by their own light, and look like characters of fire.

Phosphorus, when melted, combines with various substances. With sulphur it forms a compound so very combustible, that the instant it comes in contact with the air, it takes fire. From this composition, phosphoric matches are prepared, which are very useful for procuring light, as they kindle as soon as exposed to the atmosphere.

Phosphorus, combined with hydrogen gas, takes fire spontaneously, in the air, at any temperature. This is, probably, the cause of the transient flames, called Will-of-the-wisp, or Ignes Fatui. This gas is called phosphuretted hydrogen gas.

The combination of lime with phosphorus is termed Phosphuret of Lime, and has the property of decomposing water, by being thrown into it.

In this process, bubbles of hydrogen gas ascend, holding in solution a small quantity of phosphorus, which, when they reach the surface of the water, and come in contact with the atmosphere, detonate and exhibit the extraordinary appearance of flashes of fire issuing from the water.

Charcoal, in a state of purity, is called Carbon. Carbon forms a considerable part of the solid matter of all organised bodies. It is a component of the atmosphere, a small degree, one-hundredth part, perhaps, or less. It abounds most in the vegetable kingdom, and is chiefly obtained from wood by combustion. When the other constituent parts of vegetable substance, such as water and oil, are evaporated, the black, porous, brittle matter that remains is charcoal.

Carbon exists in many substances where we should not easily suspect its presence.

Example.—The precious stone, called diamond, is carbon in a crystallized state, and is combustible; and cotton is almost entirely composed of carbon. If charcoal be burnt in a closed vessel, with oxygen gas, the product will be carbonic acid gas. If the combustion be performed with the exact proportions of twenty-eight parts of carbon to seventy-two parts of oxygen, both these ingredients will disappear, and the result will be one hundred parts of carbonic acid.

Carbonic acid gas is produced from animal and vegetable substances in a state of vinous fermentation. In breweries, there is always a stratum of this gas on the surface of the fermenting liquor. Carbonic acid gas is formed, like-separate, are changed, or destroyed by their combination.

6. The force of chemical affinity between the constituents of a body, is estimated by that which is required for their separation.

7. Bodies have different degrees of chemical attraction for one another.

The compounds which are formed in consequence of these laws of chemical attraction are numerous and various. Of these, Alkalies and Earths are the most prominent.

The general properties of alkalies are, an acrid burning taste; and a caustic action on the skin and flesh.

There are three kinds of alkalies; Potash, Soda, and Ammonia.

Potash and Soda are called fixed alkalies, because they exist in a solid form at the temperature of the atmosphere, and require a great heat to volatilise them. They consist of metallic bases combined with oxygen.

Ammonia is called volatile alkali, because its natural form is that of gas. Potash is never found, in nature, pure and separate from all other substances. It exists, combined with carbonic acid, in all vegetables; from whose ashes it is commonly procured. When pure, it is a white caustic powder, which it is difficult to preserve in that state, because it attracts moisture from the atmosphere rapidly, and would soon be converted into a fluid, were it not completely kept from the air.

The name potash is borrowed from the pots in which the vegetables used to be burnt in order to obtain it from their ashes.

The alkali, obtained from wood ashes, purified in a certain degree, makes what is commonly called pearl-ash.

SODA.

The great source of this alkali, is the sea, in which, combined with a peculiar acid, it forms the salt with which its waters are impregnated. Soda may be obtained from common salt, but the most common method of procuring it is, from the burning of marine plants.

It derives its name from a plant called Soda; by the Arabians, Kali, which affords it in great abundance. From Kali, the term alkali in general, is derived.

Ammonia, or the Volatile Alkali, is seldom found pure in a natural state. It is commonly extracted from a compound salt, named Sal Ammoniac, and is then in the form of crystals, being a combination of ammonia and muriatic acid, and would be called more properly muriat of ammonia. The ammonia may be separated from the muriatic acid, by chemical attractions. When extracted from the salt, its natural form, at the temperature of the atmosphere, is that of gas, and is then called ammoniacal gas. But it mixes very readily with water, and may thus be obtained in a liquid form, when it becomes hartshorn, or liquid ammonia.

Ammonia may be obtained, likewise, from all animal and vegetable substances, particularly from bones and horns of animals. Hence the old name hartshorn was given to liquid ammonia.

Ammonia is caustic like the fixed alkalies, as may be seen by the pungency of hartshorn.

Under the term, Earths, are arranged all earthy, stony substances, such as rock, marble, chalk, slate, sand, flint, all kinds of stones, from the precious gems to the meanest pebbles.

There are nine earths enumerated by chemists; Silex, Alumine, Barytes, Lime, Magnesia, Strontites, Yttria, Glucina, and Zirconia.

The last three have been lately discovered, and their properties are but imperfectly known.

The earths are composed of a metallic basis, combined with oxygen, and are therefore incombustible.

Silex is found in flint, sand-stone, agate, jasper; and forms the basis of many gems, especially of those which strike fire with steel. It is very rough, scratches and wears away metals, is acted upon by no acid but the fluoric, and is not soluble in water by any known process. Yet, by some means which the human mind has not discovered, it is dissolved naturally, and produces a variety of siliceous crystals, among which is the rock crystal, the purest specimen of this earth. Silex appears intended by the great Creator to be the solid support and substratum of our globe; the foundation of the primitive rocks and mountains. It is of great value in many of the useful arts. Mixed with clay, it forms the basis of the various kinds of earthen ware; combined with potash, it helps to make glass, and it is the principal ingredient of some of the most durable cements.

Alumine is the basis of a compound salt, called allum, from which it derives its name. It would be called more properly sulphat of alumine. In its pure state, it is soft, makes a paste with water, and hardens in the fire. It is found chiefly in clay, and in that state, forms the beds of lakes and springs, and not allowing a passage to water as sand does, it constitutes an impenetrable bottom, by which means water is accumulated in the caverns of the earth, whence springs issue, and rise to the surface.

Alumine is the most essential ingredient in all pottery work. It enters into the composition of brick, and of the finest porcelain.

Lime is strongly alkaline. In nature it is not met with in its simple state, because its affinity for water and for carbonic acid is so great, that it is always found combined with those substances, with which it forms the common lime stone. Pure lime is what remains of lime stone, after it has been deprived, by heat, of its water and carbonic acid. It is then called quick lime, and is so caustic, that it is capable of decomposing, very rapidly, the dead bodies of animals, without their undergoing the process of putrid fermentation.

The attraction of lime for carbonic acid is so strong, that it absorbs it even from the atmosphere.

Example.—Expose a glass of lime water, that is, water in which lime is completely diffused, to the air; the lime will separate from the water, combine with the carbonic acid, and re-appear on the surface, in the form of a white film, which is carbonat of lime, commonly called chalk. So that chalk is a compound salt.

Breathe into lime-water, and the carbonic acid mixed in the breath respired, will produce the same effect. A white cloud is formed in the lime-water, and chalk is precipitated.

Barytes, is an earth remarkable for its great weight and strong alkaline properties. It destroys animal substances, turns some of the blue vegetable colours green, and shows a powerful attraction for acid. It is seldom used, except in chemical laboratories. Barytes is a deadly poison.

Magnesia is an alkaline earth, well known as a useful medicine. It is then in a state of carbonat, in the form of a fine white powder, which is nearly that of its simple form. Its chief use in a medicinal view, is, like that of lime, to combine with and to neutralise the acid it may meet with in the stomach.

Strontites, or Strontian, resembles barytes greatly. It is seldom in a natural state, and is of very little use in the arts. One of its characteristic properties is, that its salts, dissolved in spirits of wine, tinge the flame of a deep red, or blood colour.

QUESTIONS.

What are the laws of chemical attraction? What are the most obvious compound bodies formed by those laws? What are the general properties of alkalies? Which are the fixed alkalies, and why are they so denominated? Which is the volatile alkali, and why is it so called? Whence is potash obtained, and whence is soda procured? From what substances is ammonia extracted? What substances are com-

prehended under the term earths? What are the nine earths enumerated by chemists? What is silex, and to what useful purposes is it applicable? What is alumine, and what purposes does it answer? What is lime, and what are its chief uses? What are barytes and strontian?

CHAP. XX.

CHEMISTRY — continued.

ACIDS.

The Acids are substances characterised by very distinct properties. They change blue vegetable juices to red; they are chiefly sour to the taste; they possess a strong tendency to combine with the earths, alkalies, and metallic oxyds. Acids are composed of a certain base, united with oxygen.

Thus, sulphuric acid is a combination of sulphur and oxygen, and nitric acid is composed of nitrogen and oxygen. Acids are distinguished by the name of their respective bases, and their degrees of oxydation; that is, the different quantity of oxygen they contain is expressed by the name of their base terminating in "ous," or "ic."

Thus, sulphureous acid is that formed by the smallest proportion of oxygen combined with sulphur; sulphuric acid, that which results from the combination of sulphur with the greatest quantity of oxygen.

At present, thirty-four different acids are enumerated. They are classed under three general heads.

First, Acids of known, or of supposed simple bases.

Second, Acids of double bases, being of vegetable origin.

Thirdly, Acids of triple bases, or animal acids.

Sulphuric acid is nearly twice as heavy as water, and has an oily consistence. It was formerly called oil of vitriol, because vitriol is the common name for sulphat of iron, a salt formed by the combination of sulphuric acid and iron, from which sulphuric acid was obtained by distillation.

Sulphuric acid decomposes all combustible substances, animal, vegetable, or mineral, and burns them by means of its oxygen. It unites with all the alkalies, alkaline earths, and metals, to form compound salts.

The term salt has been used as a kind of general name for any substance that has savour, odour, is soluble in water, and crystallisable, whether it be of an acid, alkaline, or compound nature, but modern chemistry applies the term to compound salts alone.

The nitric acid exists naturally in the form of gas, but is so very soluble in water, and has so great an affinity for it, that one grain of water will absorb and condense ten grains of nitric acid gas. It has a strong disagreeable smell, contains an extraordinary quantity of oxygen, but retains it very feebly. Nitric acid burns all kinds of organized matter. To some of the most combustible substances it will even set fire.

Example.—Pour a small quantity of nitric acid on a piece of dry warm charcoal, upon oil of turpentine, or upon phosphorus, and it will immediately inflame them.

Nitric acid is obtained from nitre, or nitrat of potash, by the intervention of sulphuric acid, which, combining with the potash, releases the nitric acid. Nitric acid diluted in water is named Aqua Fortis, which will dissolve almost all metals.

Fluoric acid is obtained from a substance frequently found in mines, and particularly in those of Derbyshire. It is named Fluor, because it is serviceable in rendering the ores of metals more fluid when heated. It has the property of carrying off with it the silicious parts of glass, and thus corroding it. This power of fluoric acid has been applied to engraving, or rather etching, upon glass.

Muriatic acid is found combined with soda, lime, and magnesia. Muriat of soda is the common sea salt, and from this substance the acid is usually disengaged, by means of the sulphuric acid. Its natural state is that of an invisible permanent gas, at the common temperature of the atmosphere; but it has a very powerful attraction for water, and assumes the form of a whitish cloud, whenever it combines with moisture. Muriatic acid is remarkable for a peculiar and very pungent smell, and possesses the general properties of the acids in a very high degree. It extinguishes flame.

The highest degree of oxygenation of muriatic acid is called Oxymuriatic Acid, or Chlorine. It may be obtained by distilling liquid muriatic acid over oxyd of manganese, which supplies the additional oxygen. It is not invisible like the rest of the gasses, for it is of a yellowish green colour. It enlarges flame, and gives it a dark red colour. It is so suffocating that it cannot be breathed without great difficulty for a moment.

This gas discharges vegetable colours, burns all metals, and is the only acid that will dissolve gold and platina, and is, in fact, what is called Aqua Regia.

Oxalic acid is a peculiar acid, found in the juice of sorrel, in combination with potash. Several other substances also, and particularly sugar, contain the bases of this acid in a convenient form for being converted into oxalic acid, by combining it with oxygen; hence it is sometimes called the acid of sugar. It has a very acid taste, and is soluble in water. It is very pernicious, if taken uncombined into the stomach.

Acetic acid is principally obtained by acetous fermentation, from saccharine liquors, which have undergone the vinous fermentation. Acetic acid, as it is generally prepared, is a pleasant yellow liquor. When distilled, it is colourless as water. It is known by the name of vinegar.

Citric acid is found in the juice of lemons, and several other fruits. It is very acid to the taste, and soluble in water. It is used for various purposes in the arts.

The Prussic is a peculiar acid, composed of hydrogen, nitrogen, and carbon. It is a colourless liquid, has a sweet taste, and does not change the colour of vegetable blues. It is of great use to chemists for detecting metals in solution. It is prepared from blood, and other animal substances, and, when united with iron, forms the paint called Prussian blue. It has lately been applied to medical purposes, but its character as a medicine has not yet been decided.

Acids are extensively useful in the various arts and manufactures, which are practised and carried on for the convenience and comfort of man, in his social state. They are applied to culinary and medicinal purposes. They are continually operating in the natural world, in the animal, vegetable, and mineral kingdoms, and are important instruments in the hand of the universal Creator, for the production of many of those wonders which present themselves to our view on every side.

QUESTIONS.

What are acids, and their general properties? How many kinds of acids are enumerated by chemists? Under what heads are they arranged? Whence do the acids derive their several names? What is sulphuric acid, and what are its properties? What is nitric acid, and what are its properties? What is aqua fortis? What is fluoric acid, and what are its characteristics? When is muriatic acid obtained, and what are its chief properties? What is chlorine, &c.? What is oxalic acid? What is the acetic acid? What is the citric acid? What is the Prussic acid? Are acids of general utility?

CHAP. XXI.

CHEMISTRY—continued.

CHEMICAL PRODUCTS.

The greatest degree of cold is produced by the mixture of snow with different kinds of salts.

Ice is water deprived of its caloric of fluidity, and is esteemed by some to be thin, in its natural state; but this effect is artificially produced by freezing mixtures, and other means.

The greatest degree of heat is produced by a stream of oxygen gas, directed by an instrument called the blow-pipe; by the burning-glass, and by the Galvanic spark.

A plentiful supply of oxygen gas constitutes the principle of Argan's lamp. A current of air is made to pass through a cylindrical wick; by which means so much oxygen gas is conveyed, as that almost every particle of oil is consumed by the quickened combustion, and consequently no smoke is produced.

Soap is formed by the mixture of alkali with oily matter. A solution of potash is boiled with oil, and thus soap is produced.

Glass is formed by the fusion of potash, or soda, with silicious earth. By itself, silex is infusible; but, mixed with potash, or soda, it melts when exposed to the heat of a furnace, combines with the potash or soda, and runs into glass.

Saltpetre is formed by the combination of potash with the nitric acid.

Oil and acids are excellent antidotes against akaline poisons.

Of the salts used for medicine,—Glauber's salt is sulphat of soda; sal polychrest is sulphat of potash; Epsom salt is sulphat of magnesia. These are bitter and disagreeable, but very beneficial substances.

Gypsum, or plaster of Paris, is sulphat of lime.

Common writing ink is a precipitate of sulphat of iron by gallic acid, which acid is obtained from galls; those excrescences upon trees, are the work of insects.

Gunpowder is a mixture of five parts of nitre to one of sulphur, and one of charcoal. The constituents of gunpowder, when heated to a certain degree, enter into a number of new combinations, and are instantaneously converted into a variety of gases, the sudden expansion of which striking the air with great violence, this concussion produces that sound, or detonation, which accompanies the sudden deflagration, or inflammation of the gases.

Essences and perfumes are chiefly formed of volatile oils.

Tanning, dying, painting, are all performed by chemical extraction and combination.

Pottery and porcelain manufactures depend likewise on chemical processes.

Tartar is procured from vessels in which wine has been kept, and contains a peculiar acid, called tartaric, useful for many purposes. Cream of tartar is merely this, tartar purified, which is the super tartrat of potash.

Salt and sugar, as used at our tables, are crystals of salt and sugar.

Crystallization is the re-union of the particles of a solid body which has been dissolved in a fluid.

Crystallization is regularly performed in different figures, according to the nature of the different substances dissolved and crystallized.

The decomposition of vegetables is always attended by a violent internal motion, produced by the disunion of one order of particles and the combination of another. This is called fermentation, and is of different kinds, producing different products.

Of the saccharine fermentation, the product is sugar. Saccharine matter is found in many of the vegetable tribes.

Wines, with their consequents, are the products of the vinous fermentation.

Vinegar is the product of the acetous fermentation.

Wine distilled, yields brandy, and some other substances; and brandy distilled produces alcohol, or spirit of wine; and from alcohol, united to nitrous or sulphuric acids, is obtained ether.

Burnt sugar is used to give a reddish colour to brandy.

Alcohol contains a great quantity of hydrogen, and consequently is very combustible.

Ether is the most inflammable, as well as the lightest of all liquids.

Rum is distilled from the sugar-cane.

Arrack is the product of the vinous fermentation of rice.

Beer may be regarded as malt wine.

Alcohol may be obtained from any kind of grain.

Gin is alcohol flavoured with juniper berries.

Whisky is alcohol obtained from malt.

Distillation is the process whereby the most subtile parts of a compound body are dissolved by heat, and separated from the mass in the state of gas, or vapour. The substance which is to be submitted to distillation is placed in a glass vessel, called a retort, consisting of a bulb and a neck. The flame is applied to the bulb, and the disengaged gas passes through the neck. Digestion is the effect produced by the continued soaking of a solid substance in a liquid, with the application of heat.

CHEMICAL INSTRUMENTS.

The principal instruments used for chemical experiments and processes, are the following:

Baths. Vessels for distillation, or digestion, contrived to transmit heat regularly and gradually.

Sand-baths. Vessels partly filled with dry sand, in which those retorts are placed that require a greater heat than that of boiling water.

Water-baths. Vessels of boiling water, in which are placed other vessels, containing the matters to be distilled.

Blow-pipe. An instrument to increase flame, and to direct it in a stream upon any particular object required to be greatly heated, or melted.

Bolt-head. A round vessel with a long neck.

Calorimeter. An instrument contrived to measure the quantity of caloric disengaged from any subject which is the object of experiment.

Crucibles. Vessels made of baked earth, or metal, in the form of an inverted cone. They are used to hold substances during the operation of their fusion.

Cupel. A vessel made of calcined bones, mixed with a small proportion of clay and water. It is used in the refining of gold and silver, by melting them with lead.

Furnaces. Vessels of various forms, for the fusion of solid substances, or for any other operations which require very high degrees of heat.

Blast-furnaces are so contrived, that their heat is greatly increased by means of powerful bellows: such are the forges of smiths.

Wind-furnaces, are furnaces intended for generating peculiarly intense heat. They are so constructed as to have a violent current of air pass through them, without the aid of bellows.

Gasometers. Various utensils, contrived to measure, collect, preserve, or mix the different gases.

Hydrometers. Instruments for ascertaining the specific gravity of spiritous liquors, or other fluids.

Hygrometers. Instruments for ascertaining the degree of moisture in the atmosphere.

Pyrometers. Instruments for measuring the degrees of heat in furnaces and intense fires.

Receivers. Globular glass-vessels, adapted to retorts, for the purpose of preserving and condensing the volatile matter raised in distillation.

Retort. A vessel in the shape of a pear, with its neck bent downwards; used in distillation.

Reverbatory furnace. A furnace in which the flame is confined by a dome that occasions it to be depressed to the floor before it passes into the chimney.

Registers. Openings in chimneys, or other parts of chemical furnaces, with sliding doors, to regulate the quantity of atmospheric air admitted to the fire-place, or to open or shut the communication with the chimney at pleasure.

Syphons. Bent tubes used by chemists for drawing liquids from one vessel to another.

Test-papers. Papers impregnated with certain colouring matters, such as litmus, turmeric, radish. They are dipped into fluids, to ascertain, by a change of colours, the presence of acids and alkalies.

Worm-tub. A chemical vessel, with a pewter or hollow spiral in the inside, the intermediate space being filled with water.

QUESTIONS.

How is the greatest degree of cold produced? How is the greatest degree of heat produced? What is the principle of Argand's lamp? How is glass formed? How is saltpetre formed? What is hartshorn? How are Glauber's salt, sal polychrest, and Epsom salt formed? How is common writing ink made? Of what materials is gunpowder composed? Of what are essences and perfumes made? What is cream of Tartar? What are the salt and sugar used at our tables? What is crystallization? What is fermentation? What is the product of the saccharine fermentation? What is alcohol? What is ether? What gives the red colour to brandy? From what is rum distilled? From what is arrack distilled? From what is whisky distilled? What is gin? What is distillation? What is digestion? What are baths? Sand baths? Water baths? What is the blow-pipe? The bolt-head? The colorimeter? Crucibles? Cupel? Furnaces? Blast furnace? Wind furnace? Reverbatory furnace? Gasometer? Hydrometer? Hygrometer? Pyrometer? Receivers? Retorts? Registers? Syphons? Test-papers? Worm-tub?

CHAP. XXII.

BOTANY.

ORGANS OF PLANTS.

BOTANY is that science which treats of the nature, properties, and classification of vegetables.

Vegetables are bodies that have various parts and organs, by means of which they receive nourishment, increase their bulk, continue their species, and produce food for animals.

They differ from animals, inasmuch as that they possess the faculty of deriving nourishment from inorganic matter, such as mere earths, salts, or airs; while animals can feed only on what is, or has been, organized matter; and also, as their increase of bulk is by secretion, whereas unorganized increase by accretion.

The constituent parts of vegetables are found to be chiefly matter of heat, matter of light, oxygen, hydrogen, azote, carbon, and their combinations.

Heat excites the activity of vegetables; it promotes their growth, causing them to reject such substances as would impede that growth; it assists the digestion, formation, and secretion of their different products; it supports the irritability of their parts; renders their food and juices more fit for penetrating and passing through their various conducting tubes and canals; and by promoting perspiration and respiration, enables them to throw off their superfluous fluids. When vegetables are dead, heat occasions a dissolution of their component parts, and a new combination of them by fermentation, thus promoting the preparation of fresh food for living plants.

Light, acting upon vegetables, tends to excite heat, to separate oxygen, and to produce elastic fluids.

Living vegetables manifest a strong disposition for light; they evidently search for it, and turn their flexible parts towards the quarter whence it comes. Light seems to be necessary to the colouring of vegetables, for when deprived of it they lose their colour, and become pale or white.

Oxygen contributes to the growth, the irritability, and the colouring of plants, occasions a change in their nature as they imbibe it, and favours the production of resinous matter.

Water, of a moderate temperature, is most friendly to vegetables, as it enters their vessels, extends them, modifies the heat, conveys their food to their different parts, and gives fluidity to their juices.

Plants are regarded as living bodies, since they originate from bodies of their own kind, in an uninterrupted succession; since they assume various forms successively, from the beginning of their existence to their final decay, and since they grow by receiving extraneous substances into their own composition, through vessels or organs.

When the organs of plants are deprived of the power of receiving food, and converting it into nourishment, they die, and their death is followed by the decay of their bodies, and the decomposition of their component parts.

In plants are observed uninterrupted motion, occasioned by the vital power, or by external stimulus; and interrupted motion, occasioned by internal or external stimulus; but plants do not exhibit any signs of perception or voluntary motion.

Though plants receive their food through numerous canals or mouths, yet they digest that food in nearly the same manner as animals. The substances so received are changed by the peculiar internal operations of the plants, and are so prepared for entering into their proper constitution, and for the formation of their products. Like animals, they also eject from them superfluous matter, by respiratory organs, and by other secretions.

Plants perspire, likewise, liquid and permanent elastic fluids.

Sleep is common to plants, with animals, but during their sleep the action of their organs does not cease, it is only modified.

Plants regularly reproduce in spring and autumn the cuticles and leaves which have decayed.

They have also the power of reproducing such of their parts, as may have been accidentally destroyed.

The various species of vegetables are continued either by their seed, or artificially, by nourishment applied to slips or cuttings from them, so as to cause them to become entire plants by reproduction.

The principal organs of plants are the root, the stem or trunk, the leaf, the flower, and the fruit or seed.

The root fixes the plant to the earth, and is the chief source of its nourishment.

Rootshave fibres at their extremities, by which they collect nourishing substances. They consist internally of a cuticle, or thin skin, bark, wood, and generally a small quantity of pith; and they are furnished with a variety of vessels, for the purpose of conveying and circulating air, and the juices necessary to the nutriment of plants.

The stem, which includes the branches, and all the more solid parts of the plant or tree, consists of the bark, the wood, and the pith.

Leaves serve as lungs, for the inspiring and respiring of air, or other elastic fluids; and for the exposure of the sap to the influence of air, light, and heat. Trees die, if they are entirely divested of their leaves, and are injured by the removal of any considerable portion of them.

The flower, the most beautiful part of the plant, is the seat of fructification, or of producing those seeds which are destined to raise new plants. The flower is composed of four parts, the calyx, the corolla, the stamens, and the pistil.

The calyx, or cup, which is almost always green, supports the other parts of the flower.

The corolla rises out of the calyx, and is of different forms and colours in different vegetables. Sometimes it consists of one undivided piece, called petal, but more frequently it is separated into several petals.

The stamens are generally placed around the pistil, and usually consist of filaments, supporting anthers, which contain the pollen or fine dust, which is seen of different colours in many flowers. When the pollen comes to maturity, the anthers burst, and scatter it upon the pistil or pointal, which rises commonly from the centre of the corolla, surrounded by the stamens.

The pistil consists of the germen, which afterwards becomes the seed-vessel; and the style, which rises above the germen, and supports the stigma, or summit of the pistil, covered with moisture, in order to retain the pollen, or farina, which is the fructifying dust. When the germen is arrived at maturity, it is called the pericarpium, or seed-vessel. The only necessary parts of a flower are the germen, the stigma, and the anthers.

Every flower is completely formed in its bud long before it comes forth to view.

Thus, if a tulip root be carefully opened, about the beginning of September, the flower which would have appeared from it the following spring, will be discerned, folded up in a small cell, formed by the innermost coats of the bulb.

The fruit of vegetables consists of a skin, or cuticle, or rind, inclosing a pulpy substance, in the midst of which is the core, a hard membrane, that holds the seed. But the organization of the fruit is very much varied. In some fruits the seeds are dispersed throughout the pulp, as the strawberry, the raspberry, &c.; and in others the seed is inclosed in a hard, thick, woody case. In others, instead of the core, is found a strong and very hard woody substance, inclosing the seed or kernels, as stone fruits of all kinds.

The seed is that part of any vegetable which contains the rudiment of a new plant of the same kind, and which, at the proper season, naturally separates from it. It is supposed that the perfect plant, or, at least, all the organization necessary to the perfect plant, is contained in the seed, surrounded by farinaceous, or mealy matter.

In every seed may be distinguished the organ of nourishment, the plume or infant plant, the radicle or infant root.

Plants, whose roots are bulbous, generally increase most rapidly by off-sets. The stem rises from the middle of the bulbous root of the tulip, when it is planted in the spring; but if it be taken up in autumn, the stem will be found not proceeding from the middle of the root, but attached to one side.

The root taken up at that season is not the same that was planted, but a new one provided, the original root having been exhausted in affording nourishment to the blossom.

QUESTIONS.

What is botany? What are vegetables? In what respects do vegetables differ from animals? What are the constituent parts of vegetables? What effects have heat; and light, and oxygen, upon vegetables? Why are plants regarded as being living bodies? When are plants said to die? What motions are observed in plants? Do plants digest their food? Do plants perspire? What is the sleep of plants? What powers of reproduction have plants? How are the various species of vegetables continued? What are the principal organs of plants? What is the root? The stem? What are the leaves? What is the flower? What is the calyx? The pistil? What is the corolla? What are the petals? What are the anthers? What are the stamens? What is the pollen or farina? What are the germen, the style, and the stigma? What is the seed? What is the fruit? What parts of the vegetable are distinguishable in every seed? How do plants, whose roots are bulbous, generally increase?

CHAP. XXIII.

BOTANY—continued.

ORGANS OF PLANTS.—JUICES OF PLANTS.

THE smaller organs of plants are organs of secretion, for the forming of juices; and organs of motion.

The organs of secretion, are sap vessels;

pith vessels; nutritious vessels, and lymphatic vessels.

The organs of motion are, fibres; some of which are straight, others circular, and others spiral.

The juices of plants, are either common, that is, diffused through all parts of their bodies; or particular, that is, found only in particular parts of their bodies. The perspirable matter of plants appears to differ in no respect, from water, excepting that it becomes putrid rather sooner.

The perspiration of plants varies according to the quantity of their leaves, and the degree of light and heat to which they are exposed. A sunflower, weighing three pounds, was found to have perspired twenty-three ounces, in twenty-four hours; which is a much larger quantity in proportion to its weight, than the human body perspires in the same time.

The principal substances found in vegetables are, gum or mucilage, starch, sugar, albumen, gluten, gum elastic, extractive matter, tannin, indigo, narcotic principle, or principle inducing sleep, the bitter principle, wax, resins, camphor, fixed oils, volatile oils, woody fibre, acids, alkalies, earths, metallic oxydes, and saline compounds.

Gum is a substance which exudes from certain trees; and is very abundant in the vegetable kingdom. The most common gums, are gum arabic, which is obtained from a species of acasia, in Arabia and Egypt; gum tragacanth, which is the product of a thorny shrub, an acanthus, growing in Crete, Asia, and Greece; gum senegal, and the gum of the plum, and of the cherry tree.

Starch is a mucilaginous substance, which is procured from various vegetables, but particularly from wheat and from potatoes.

Starch is prepared from wheat in this manner. The grain is soaked in cold water, until it becomes soft, and yields a milky juice by pressure. It is then put into linen sacks, and pressed in a vat filled with water. The pressure is continued as long as the milky juice exudes. After which the fluid gradually becomes clear, and a white powder subsides; which is starch.

Starch constitutes a principal part of many vegetables fit for food. Cassava, salep, and sago, owe their nutritive quality chiefly to the starch they contain.

Sugar is a very nutritious substance, of a sweet taste, which is found in a variety of vegetables; such as the maple, the birch, the red beet, the parsnip, the grape, farinaceous grain, and especially the sugar-cane. The sugar-canes, when ripe, are crushed between iron rollers, and thus the saccharine juice is extracted. The acid in this juice is then neutralised by the application of lime; and by the evaporation of the watery parts of the juice, and by slow cooling, the sugar is crystallized; it is rendered white by the gradual filtration of water through it.

Albumen, in its pure form, is a thick tasteless fluid, like the white of an egg, and is soluble in cold water. It is found in the mushroom and in various kinds of fungi. The chief part of the almond, and of the kernels of many other nuts, appears to be coagulated albumen.

Gluten is a tenacious, ductile, elastic, tasteless substance, which, when exposed to the air, contracts a brown colour. It is found in a great number of plants, such as acorns, horse-chestnuts, apples, chestnuts, quinces, barley, peas and beans; but it abounds most in wheat, and as gluten is one of the most nutritive of the vegetable substances, wheat owes to this circumstance its superiority to all other grain: no substance is capable of vinous fermentation which does not contain gluten.

Tannin is a yellow substance of a very astringent taste. It is of great importance in the art of tanning, or converting skins of animals into leather. When animal skin is exposed to the action of tannin in solution, it slowly combines with it, losing its gelatine or jelly, but retaining its fibrous texture and coherence. Thus it is rendered insoluble in water, and capable of resisting putrefaction. In this country, the bark of the oak is generally used for affording tannin in the manufacture of leather; but the barks of many other trees yield the tanning principle in various proportions; such as the chestnut, the willow, the ash, the beech, the poplar.

The narcotic principle is found abundantly in opium, a substance obtained from the juice of the white poppy. It has neither taste nor smell. The influence of opium upon the human frame, inducing sleep, and even death, if taken in sufficient quantity, depends upon this principle. In a smaller degree, the narcotic principle is found in the garden lettuce and in various other vegetables.

The bitter principle is very extensively diffused throughout the vegetable kingdom. When extracted, it is generally of a pale yellow colour, and is extremely bitter to the taste. In the hop, in camomile, in quassia, and in the common broom, it exists in great abundance. It is extracted from these substances, by the action of water, or of alcohol, and by evaporation. It is of great importance in brewing, as it checks fermentation, and preserves fermented liquors from turning sour. It is applied also to a number of medicinal purposes.

Wax is a white substance, insoluble in water, and combustible, which appears to be of the same nature as that which is prepared by the curious and industrious animal, the bee. It may be procured from the berries of a species of myrtle, and from the leaves of various trees.

Resins are vegetable juices dried; and are commonly procured from wounds made in the trunks of trees. One of the most common species is that of the different kinds of firs. Tar and pitch consist principally of this resin. Tar is extracted by the slow burning of fir, and pitch is prepared by the evaporation of the more volatile parts of tar.

Camphor is a vegetable substance, of a very peculiar and strong odour, and acrid taste, white, brittle, and semi-transparent.

It is procured, by distillation, from the wood of a species of laurel, which grows in China, Japan, and others of the eastern Asiatic islands. Small quantities of it are found, also, in thyme, rosemary, and some other vegetables.

Fixed oil is a smooth, greasy substance, which is not emitted from the surface of vegetables, but is procured from their kernels, by pressure. The olive, the almond, linseed, and rapeseed, afford the most common vegetable fixed oils. Castor oil is obtained from a shrub called Palma Christi. The fixed oils are very nutritive, and of great importance to medicinal purposes, and to many of the conveniences of life.

Volatile, or essential oils are distinguished by a strong aromatic smell; and are so volatile or light, as to be disengaged by the heat of boiling water, and to rise.

The volatile oil of cinnamon is found in the bark, but in the leaves of balm, peppermint, and wormwood; in the flowers of the rose and lavender; and in the seeds of the nutmeg and fennel. These oils are obtained by pressure, or by distillation.

The volatile oils are not used as articles of food, but many of them are employed in various arts and manufactures.

Woody fibre is an insoluble matter, which is the basis of the solid, organized parts of plants. It burns with a yellow flame, and from it, charcoal is procured for the common purposes of life.

Fixed alkali, is a substance that may be obtained from most plants by burning them, and treating their ashes with quick lime and water. The common alkali of vegetables is potassa or potass, which, in its pure state, is white, nearly transparent, of a very caustic taste, and requiring a very strong heat for its fusion.

Soda, or mineral alkali, is found in some plants that grow near the sea.

Pearl ashes, barilla, and kelp, or the impure soda procured from the ashes of marine plants, are very valuable in commerce, principally on account of their use in making soap and glass.

QUESTIONS.

What are the smaller organs of plants? What are organs of secretion? What are the organs of motion? What are the juices of plants? What are the compound substances found in vegetables? What is gum? What is starch? What is sugar? What is albumen? What is gluten? What is tannin? What is the narcotic principle? What is the bitter principle? What is wax? What are resins? What is camphor? What is fixed oil? What is volatile oil? What is fixed alkali? What is soda or mineral alkali?

CHAP. XXIV.

BOTANY — continued.

ODOUR. — FARINA. — BREAD. — MALT.

The scent, or odour, of vegetables, consists of particles emanating from their leaves and flowers, which particles possess the property of exciting the olfactory nerves in animals, and are thence called odoriferous.

Vegetables have the property of purifying bad air; as they emit vital air, when acted upon by the rays of light. In general, however, oxygen emanates only from those parts of plants which are green, and not from the epidermis, the bark, or the petals; and it is emitted with the same facility by all plants. In some the process is slow; while others, such as the lavender, give out vital air the instant the sun-beams begin to act upon them. The oxygen flows from the lower sides of the leaves of trees; while herbaceous plants afford it from almost the whole of their surfaces. Thus plants vegetating in atmospheric air which has lost its oxygen by respiration of animals, or by combustion, restore it to a state of purity.

The nourishment of vegetables, in whatever manner it is received by them, consists principally of water, with portions of the earths and gases. Vegetables are endowed with the property of separating from water the minute portions of nourishment it contains, so that many herbs will grow in nearly pure water.

Flour of farina, is the substance of the seeds of certain grasses reduced to fine powder.

The seeds of wheat yield the most valuable farina.

From the farina of grain, bread is made. The flower is formed into paste by being wetted with water, and then dried by baking. The bread which is in common use, is leavened; that is, made to ferment by mingling yeast, or some other product of fermentation with it, and keeping it in a warm temperature. By this means, air is extricated from it; its particles are separated, and the whole mass swelling, becomes porous. This extension is increased by the rarefaction of its air, by the heat to which it is exposed in the process of baking. Thus is formed a substance nutritive and easily digestible.

Unleavened bread, or biscuit, keeps longest without corrupting, and bread is, therefore, so prepared for long voyages, or journies, during which the operation of baking would be inconvenient.

From the seeds of the grass called barley, malt is prepared; and from malt is made the drink called beer.

To generate as large a quantity as possible of the saccharine matter in the grains, the barley is first completely immersed in water for fortv hours; by which the grains are softened and swelled, so as to give room for the blades inclosed in them to shoot. The water is then drained off, and the moistened barley is transferred from the cistern in which it had been thus steeped, to the couch, which is a kind of inclosure formed near the cistern, by means of moveable sides, or shutters, of wood. When the process of germination is begun, the barley is spread out upon a level floor, where it is very frequently turned, and suffered to remain till the radicles are projected from the barley-corns to a certain length, and the plumes are just ready to protrude themselves from their upper points. The barley is then conveyed to the kiln, the floor of which is made of bricks, or of iron, where, by different degrees of heat, it is dried more or less quickly, according as pale beer, or high-coloured porter is intended to be made from it. This stops the vegetation of the barley, and retains in each grain its full share of saccharine matter. When the barley is thus converted into malt, it is ground in a mill, or crushed between cylinders, and then thrown into a vessel called the mash tub. From the furnace, or boiler, warm water is then poured upon it, in which it is well stirred, either by the labour of men, or by a machine invented for that purpose, until a complete infusion be made of it. This infusion, named wort, is then conveyed to the copper, in which it is boiled, as long as it is judged proper; a proportionate quantity of hop blossoms being added.

From the copper, the wort is conveyed into wide shallow vessels, called coolers; and from them, while it still retains some degree of heat, it is removed into a large tub, named the gyle; and barm or yeast is applied to it, to quicken the process of its fermentation. Thence it is transported into barrels, tò complete its working off, or fermentation. When that process is finished, the liquor, then become beer, is fined by hops boiled in beer, and the barrels are closed. Hops are used in brewing beer, because they are found to be a preservative from acidity, and to impart a peculiar flavour, slightly bitter, but aromatic and pleasant.

QUESTIONS.

What is the scent or odour of vegetables? How do vegetables purify bad air? Of what does the nourishment of vegetables principally consist? What is the flour or farina of vegetables? Which of the grasses yields the most valuable farina? How is bread prepared? What is biscuit? How is malt prepared? What is the process of brewing?

CHAP. XXV.

BOTANY—continued.

CLASSIFICATION.

BOTANISTS have endeavoured to distinguish the varieties of plants by arranging them in different classes, according to the different formation of their various parts. The systems of classification are almost all deduced from some part, property, or peculiarity of the plants arranged by them. Some are derived from the fruit; some from the corolla; some from the calix; some from the number, proportion, and situation of the stamens, as that of Linnæus, while that of Jussieu is founded upon the mode of germination, and the situation of the stamens, but principally upon the number and disposition of the petals.

The Linnæan system of classifying, has been the most generally adopted; but that of Jussieu is now gaining great prevalence.

Linnæus has divided the vegetable kingdom into 24 classes. These classes are subdivided into about 120 orders; which orders contain about 2000 families, or genera; and these families comprehend nearly 20,000 species. The names of the classes are derived from Greek words, and express the distinguishing characteristics of each class. The first twelve are compounded from Greek numerals, and the word andria, forming their termination, is used to denote stamens.

The following are the 24 classes, with their respective characteristics; and the examples may be given of them.

EXAMPLES.

1. Monandria,—1 stamen,	Marestail.
2. Diandria,—2 stamens,	Speedwell.
3. Triandria,—3 stamens,	Irides and grasses.
4. Tetrandria,—4 stamens,	Teasel.
5. Pentandria,—5 stamens,	Honeysuckle.
6. Hexandria,—6 stamens,	Lilies, Hyacinth.
7. Heptandria,—7 stamens,	Wintergreen.
8. Octandria,—8 stamens,	Mezereon.
9. Enneandria,—9 stamens,	Gladiole.
10. Decandria,—10 stamens,	Pink.
11. Dodecandria,—12 stam.	Houseleek.
12. Isocandria,—20 stamens,	Strawberry and many fruit trees.
13. Polyandria,—numerous stamens,	Poppy.
14. Didynamia,—6 stam., 2 longer than the others,	Foxglove.
15. Tetradynamia,—6 stamens, 4 longer than the others,	Stock Gilliflower.
16. Monodelphia, — 1 brotherhood; threads united at bottom, but separated at top,	Rose Mallow.
17. Diadelphia, — 2 brotherhoods; threads in 2 sets,	Everlasting Pea.
18. Polyadelphia, — many brotherhoods; threads in many sets,	St. John's Wort.

19. Syngenesia, — 5 stamens, united by the anthers,	Dandelion.
20. Gynandria,—pistils and stamens together,	Orchis.
21. Monœcia, — stamens and pistils in separate flowers upon the same plant,	Cucumber.
22. Diœcia,—stamens and pistils distinct upon the different plants,	Hop.
23. Polygamia, — having stamens and pistils on the same flower, and also on the same root,	Ash.
24. Crytogamia, — invisible flowers,	Ferns, Mosses, Liverworts, Mushrooms.

The Corolla includes two parts, the Petal and the Nectary. The petal is either simple and undivided, as in the primrose, in which case it is called monopetalous, that is, consisting of one petal; or else it is compound, as in the rose, when it is called polypetalous, or consisting of more petals than one. The corolla is greatly diversified in form, according to the several genera.

Many flowers are generally ranged (perhaps with advantage), in the following classes. Liliaceous (all of the lily tribe), cruciform, or in the form of a cross. Ringent, gaping like the mouth of an animal. Personate; closed by a kind of palate; or being something like a mask. Campanulate, or bell-shaped. Papilionaceous; spreading in the form of a butterfly. The petals of which such a flower consists, are distinguished by appropriate terms. The large petal at the back of the corolla is called the standard. The two side petals are named wings; and beneath them is the keel, consisting of two petals inclosing the internal organs. Rotated, or wheel-shaped flowers. Umbelliferous flowers; standing upon small stems, diverging from the main stem like the metal rods which open an umbrella. Infundibiliform, or funnel-shaped. Cruciform flowers, such as the wall-flower. The Nectary is that part of the corolla in which is secreted that sweet viscid liquor called honey. But honey is not absolutely confined to the flowers of plants. The glands on the foot-stalk of the passion-flower yield it, and it exudes from the flower-stalks of some liliaceous plants. The only use of which honey is now supposed to be to plants is, that it attracts insects, who, in their search after it, assist to fertilize the flower by disturbing the dust of the stamens; and who even convey the fructifying pollen to those flowers by which it is not produced, and which would otherwise be barren.

QUESTIONS.

How have botanists endeavoured to distinguish the varieties of plants? Upon what is the classification of Linnæus founded? Upon what is the system of Jussieu founded? How has Linnæus divided the vegetable kingdom? What is the name of Linnæus's first class? What is its characteristic, and what is its example? Of the second? Of the

third? Of the fourth? Of the fifth? Of the sixth? Of the seventh? Of the eighth? Of the ninth? Of the tenth? Of the eleventh? Of the twelfth? Of the thirteenth? Of the fourteenth? Of the fifteenth? Of the sixteenth? Of the seventeenth? Of the eighteenth? Of the nineteenth? Of the twentieth? Of the twenty-first? Of the twenty-second? Of the twenty-third? Of the twenty-fourth? Of what parts does the corolla consist? What is the nectarium? Of what use is honey to plants? What are cruciform flowers? What are ringent flowers? What are personate flowers? What are campanulate flowers? What are papilionaceous flowers? What are rotated flowers? What are umbelliferous flowers? What are infundibiliform flowers?

CHAP. XXVI.

BOTANY — continued.

GROWTH OF PLANTS — TREES AND SHRUBS REMARKABLE FOR UTILITY AND BEAUTY.

When the seed of any plant is committed to the ground, after a certain time, which time varies greatly with respect to different plants, a fermentation takes place in the interior of the seed, which swells, and at last bursts. The plume is protruded upwards, and the radicle downwards; and so invariable is the law by which this process is conducted, that if the seed be placed in the ground with the radicle part uppermost, the plume will turn itself to rise from beneath, and the radicle will turn itself to descend from its unnaturally elevated position. The inner part of the seed is called the cotyledon; and this cotyledon furnishes nourishment to the young plant until its organs are sufficiently developed, to derive nourishment for itself from the surrounding elements. The plume becomes the stem, through which the sap rises from the root, and by means of the sap vessels circulates through every part of the plant. The leaves, the buds, the flowers, the fruits are regularly produced; and finally, seeds for the multiplication of the plant. Plants whose cotyledons divide into two lobes upon the opening of the seed, are called dicotyledonous, and form one of Jussieu's classes.

In the tropical regions, so great is the force of vegetation, that plants attain to an astonishing size. Trees are there seen rising to the height of one hundred and fifty feet, having trunks of fifteen feet diameter. The ferns, which, in cold, and even temperate climates, are diminutive plants, there rank among large trees. The leaves of some trees, such as the talipot, are large enough, each, to afford shelter from the sun or rain for several men. Some trees afford salutary oils; others, substances like bread, butter, tallow and wax, some give materials for clothing and habitation, as well as food; while others furnish offensive and defensive weapons.*

Trees and shrubs remarkable for beauty or usefulness.

The almendroon, juvia, or bertholletia. This is one of the most majestic trees of the vast forests on the shores of the Rio Negro, in South America. It attains to the height of 120 feet.

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* Men have devised artificial modes also of propagating plants; the chief of which are grafting and budding.

Its leaves are more than two-feet long; on their under side, of a silvery hue; and make the branches bend downwards towards the ground. It is a dicotyledonous plant. Its fruit, the pericarp, or case, of which, is very hard, and half an inch thick, is as large as the head of a child; often twelve or thirteen inches in diameter. It contains a number of flat triangular seeds, which are called almonds, or chesnuts of Brazil; the taste of which is extremely agreeable, as long as they are fresh; but the oil with which they abound, and which is useful in the arts, becomes easily rancid. When these fruits are ripe, they fall, and render travelling in those forests very dangerous, at that season, so that the natives cover their heads and shoulders with bucklers of very hard wood to guard against the danger of being wounded by them. Falling from such a height, they descend with great momentum, and make a fearful noise, as they crash the branches of the lower trees.

The pihiguao, or pirijao palm is a valuable and extraordinary tree. Its trunk, armed with thorns, is more than sixty feet. Its leaves are pinnated, very thin, undulated and frizzled towards the points. The fruits of this tree hang in clusters of from fifty to eighty. They are, at first, yellow; but in proportion as they ripen, grow purple, and are without kernels. These fruits furnish a farinaceous substance as yellow as the yolk of an egg; slightly saccharine, and extremely nutritious. They are eaten like plantains or potatoes, boiled or roasted in the ashes, and afford an aliment as wholesome as it is agreeable.

Among the vast variety of palm-trees, the mountain-cabbage stands conspicuous for its great usefulness. This tree grows to the height of fifty feet. The trunk is of a brown colour, hard, ligneous, divided into short joints and full of pith; straight and tapering. Near the summit it assumes a fluted form and green colour, occasioned by the husky tegument that forms the branches; which, near the summit, diverge in a horizontal direction, like the crown of a pine apple. These branches are covered over, on both sides, with strong pinnated leaves, about three feet long; of a deep green, and sharp pointed. The seed is inclosed in brownish spatha, that arises from the centre of the branches, and hanging downwards, consists of small roundish nuts, not unlike a bunch of dried grapes. In order to obtain the part called the cabbage, the tree is cut down, and divested of its branches and of the husky fluted tegument which forms them; then, the heart or cabbage is taken out. This is white, and about two feet long, as thick as a man's arm, and round like a polished ivory cylinder. It is composed of a kind of tender longitudinal white flakes, like silk ribbands, ready to form the succeeding green tegument, but so close that they appear like a solid body.

When eaten raw, this substance resembles in taste, the kernel of an almond, but is more tender and delicious. When boiled, it has nearly the taste of the cauliflower.

The cocoa-nut tree is without thorns or prickles, leaf-stalk pinnated, the leaves sword-shaped and bending back. This tree is found in India, and in different parts of Asia and America. Its trunk, which attains to the height of sixty feet, is crowned with a bunch of ten or twelve leaves, each leaf being from ten to fifteen feet long, and composed of a double range of flag-shaped leaflets. From the centre of these leaves, rises a straight, pointed tender bud, which is esteemed a great delicacy. At the lower part of the bunch of leaves, and close to the stem, is seen a large, oval, pointed sheath, whence issues a pannicle covered with yellow flowers, which produce the well-known fruit called the cocoa-nut. It is about the size of the human head. Its external case or pericarpium, is extremely thick and hard, and covered with long woody filaments. This includes a white and firm nut, inclosed in a strong case. The nut itself has but little taste, but from it is expressed an oil, which is applied to various purposes. When the nut is half ripe, it contains a considerable quantity of a watery fluid, of a pleasing smell, and agreeable taste. This is called the milk of the cocoa-nut, and in regions where the heat of the sun is extreme, is a salutary and refreshing beverage. The cocoa-nut tree grows slowly, but is long lived, and bears fruit three or four times a year. The different parts of this tree are useful in many respects. The light porous substance which grows among the branches is manufactured into a kind of coarse cloth which serves for wrappers, and rice bags; of the outer rind are made ropes, cables and cordage for ships. The branches afford posts and rafters for cottages, while the leaves are employed to cover their roofs, and to form baskets and various other domestic utensils.

Bread-fruit tree, or artocarpus. This tree is about the size of a middling oak; its leaves are about a foot and a half, sometimes three feet long, deeply sinuated like those of the fig-tree, which they resemble in colour and consistence, and in yielding a milky juice when pressed. It belongs to the dicotyledonous class. The fruit is of nearly the size and shape of a newly born infant's head; and the surface is reticulated or resembling a net. It is covered with a thin skin, and has a core about as large as the handle of a small knife. The eatable part lies between the skin and the core. It is white as snow, and sometimes of the consistence of new bread. This fruit requires to be dressed before it is eaten. It is then soft and somewhat like a boiled potatoe. The bread fruit, variously prepared, not only serves as a substitute for bread among the inhabitants of Otaheite and the neighbouring islands, but also composes a principal part of their food.

The tallow tree. Leaves smooth, of a roundish rhomboidal shape, and having spines on both sides. This extraordinary tree grows naturally in China, where it is found on the banks of rivulets. It resembles the cherry in its trunk and branches and the black poplar in its foilage. The leaves are of a bright red colour, are not toothed, and have two small glandules seated at the base of each. The fruit is contained in a husk divided into three spherical segments, which open when it is ripe, and discover three white grains of the size of a small walnut. In order to obtain this vegetable tallow, the pulp which covers the seeds, and which resembles tallow in colour, smell and consistence, is collected. It is then melted and made into candles, with the addition of a little linseed oil, to render it softer and sweeter.

The butter tree. This tree which grows in the interior of Africa, is of a moderate size with long alternate leaves. It produces a fruit, about the size of a walnut of an aromatic smell. Within the fruit is a kernel nearly as large as an acorn. From this, the vegetable butter is prepared, by first drying the kernel in the sun, and then boiling it in water. This preparation very nearly resembles butter, possesses a very rich flavour, and will keep, during a whole year, without salt.

The cotton plant. This useful plant is found in the East and West Indies, in the islands of Cyprus and Candia, Malta and Sicily, and in Syria. The corolla consists of five petals, containing many stamens united at the base into a column, and bearing kidney-shaped anthers. From a roundish germen, proceeds a style, crowned with three or four thick stigmas. The capsule is of the size of a small egg of an oval figure, divided into three or four compartments full of green or black seeds, surrounded by a white, yellowish, or reddish down. This down is the cotton, of different degrees of length and fineness. When the down is ripe it bursts the pod, and spreads itself over the side of the capsule.

The date-tree. This useful tree is a species of the order of palms. It has long been esteemed by the inhabitants of Asia and Africa, as the most beneficial production of the vegetable world. Its fruit provides them food during the greater part of the year; and its stem, branches. and leaves, contribute to the conveniences of their life.

The trunk of the date-tree, which grows to the height of thirty or forty feet is straight, and thickly studded, on the upper part, with scales, which are the vestiges of old leaves, and which exist many years after the leaves have fallen. The stem is terminated by a large bunch of winged leaves, about nine or ten feet long, composed of two rows of leaflets, mostly alternate, and of a sword-like form. The outside leaves spread like an umbrella, bending a little towards the earth; those nearer the centre are more elevated, and from the middle of them, shoots up a large conical, succulent bud. The lower part of the tree produces a number of stalks about four or five feet high. The fruit, which is shaped like an acorn, is composed of a thin light glossy membrane, somewhat pellucid, and yellowish. It is soft, pulpy, firm and sweet, and somewhat viscous to the taste, esculent, and wholesome. Within this is a solid, hard kernel, of a pale grey, convex on one side, and furrowed on the other. The date-tree grows naturally, and is, also, cultivated in the sandy regions of India, Arabia, the northern parts of Africa, the south of Spain, and the southern islands of the Mediterranean. To the people of hot and dry countries its fruit is peculiarly grateful and refreshing.

This tree belongs to the class Diœcia, the male and female flowers of which, that is, those flowers which have pistils without stamens, and those which have stamens without pistils, grow on different plants. Unless the male plant be in its vicinity, the female plant will not produce fruit, so that to insure a crop, the Arabs make an incision in the stem of each branch they wish to become prolific, and place in it a stalk of male flowers. It is the same case with the hop, with the cucumber, and other vegetables of the classes Monœcia and Diœcia.

The wax-tree. This extraordinary shrub grows in North America; principally Pennsylvania, Carolina and Virginia. It belongs to the class diœcia; has leaves lanceolate and slightly serrated; and produces a berry which yields a useful kind of wax. The berries are boiled, and pressed from time to time against the sides of the vessel in which they are placed, in order to detach the wax from them. This substance is soon seen floating on the surface of the water in the form of grease. It is then collected and strained through a coarse cloth in order to separate from it any extraneous substances. The wax is then put on linen that the water may be drained from it. It is then dried, melted, and strained off a second time to render it perfectly pure; and finally kneaded into cakes for use. Four pounds of berries yield about a pound of wax, which is, at first, yellow, but, at last, becomes of a greenish tinge.

The tea-tree. This shrub is a native of the Japan islands and of China, which does not arrive at its full size, till it is six or seven years old; when it commonly attains the height of four or five feet. The root is black, woody and branched; the stem divides into several irregular branches, covered with a thin bark, and tinged with green towards the extremities of the young shoots. The leaves resemble those of the black cherry-tree. They are in great abundance; serrated, of an intense green; and disposed alternately upon the branches. The flowers spring from the axils of the leaves, that is, their place of juncture with the stem. They are, when full grown, of a white colour, and resemble in figure, those of the common wild rose. The calix is divided into five or six segments; the corolla consists of eight or nine petals, the stamens are very numerous. The style is unique placed in the centre of the stamens, and the germ, to which it is connected, becomes, when ripe, a tough capsule usually composed of two or three partitions, each containing a roundish stone that incloses a kernel, whence the Chinese express an oil, which they apply to some particular purposes. This shrub delights in sheltered valleys; the declivities of hills, or the banks of rivers, in a southern aspect. The leaves are gathered with great care; dried in iron pans, or in earthen vessels, over fires, and finally, are curiously packed up for exportation, in chests lined with thin plates of a mixture of lead and tin.

The coffee-tree. Class five; Pentandria. This tree appears to be a native of Arabia, but is now successfully cultivated in the West India islands, and other countries similarly situated. It is an evergreen of quick growth, rising to the height of fifteen or twenty feet. Its stem is straight, bearing a number of branches opposite to each other, furnished with oval leaves, somewhat resembling those of the common laurel. In the angles of these leaves appear small bunches, consisting of four or five white flowers, of a pleasing odour, and resembling the jasmin in figure. Each flower is supported upon a short foot-stalk, and is composed of a monopetalous corolla, in which are five stamens, and a pistil having two stigmas. The germen is an oval berry, with an umbilicus, containing two seeds, flat, and furrowed on one side. When dried, roasted, and ground, these form the article so well known under the name of coffee.

The olive-tree. This useful plant, whose fruit is so agreeable and nutritious, and yields so delicate an oil, is an evergreen, whose leaves are oval, placed opposite to each other, having the upper surface of a pale shining green, the lower surface of a whitish colour. The flowers are disposed in bunches, which spring from the axils of the leaves; the corolla is monopetalous, its colour is white, and it exhales a pleasing fragrance. The olive-tree is supposed to be a native of the south of Europe, but grows, also, in the north of Africa, in many parts of Asia, and in most of the temperate climates. Its stem attains to the height of twenty feet. The olives, which are intended to be kept, are gathered before they are ripe, and put into a tub of pickle, consisting of salt and water, flavoured with coriander, fennel, and rose wood. Olives, perfectly ripe, are soft, and of a dark red colour. When the olives are gathered, they are put into baskets, or bags, made of wool or hair, and pressed immediately, in order to extract the fine oil. The oil obtained from the pulp only of the fruit, is the purest and best, while that which is procured from the kernel, or from the whole olive, ground in public mills, soon loses its limpidity, and is apt to become rancid.

Fir-tree. This tree is one of an extensive genus, well known for the great utility of timber, as well as for the resinous substances which it affords. The different species generally grow to a considerable height, and are found in various parts of Europe, Asia, and America.

The Scotch fir, or wild pine, grows naturally in the Highlands, where the trees propagate themselves by the seeds which fall from their cones. But this tree is common, also, in other countries, whence it is sometimes called the Russian pine, and the pine of Geneva. The scientific name of this pine is Pinus Sylvestris: The timber of this kind of fir, which we call deal, is red, yellow, or white, and from these trees are obtained the best masts for the navy.

Nearly approaching to this in value is the Pinus Strobus, or Weymouth pine. Large extensive woods of this tree are found in North America, where some of them are said to grow to the heighth of 200 feet.

Pinus Larix, or the larch, another kind of fir, is a native of the mountains of the Alps and Appenines, but is now become common in our own country. From this tree is obtained the substance which is improperly called Venice turpentine, and the inner part of it yields a gum, scarcely inferior to gum arabic.

Pinus Abies, or spruce fir, yields also a turpentine, from which is prepared what is called Burgundy pitch.

The generic character of the fir-tree, which is assigned to the class Monœcia Philadelphia, is, male, calyx of four scales, and no corolla; female, calyx, cone somewhat egg-shaped, and composed of scales with two flowers in each, no corolla; seed-vessel none, the seeds being inclosed within the scales of the cone.

These trees furnish masts, planks, wood for various purposes, turpentine, and tar, from which pitch is prepared by evaporation.

The Aloe, class six, Hexandria. This is a perennial plant, many varieties of which are found in the southern regions of the old and new world. The extract from this plant possesses very useful medicinal purposes. The purest is that which is brought from the isle of Socotra.

Its surface is glossy and clear, its colour red, with a purplish tinge. Its taste is bitter, but accompanied with some degree of aromatic flavour. Its odour is not unpleasant, resembling that of myrrh.

The flower of this plant is monopetalous. Its capsule is oblong, triangular, and divided into three partitions. Its seeds are numerous.

The American aloe, when in blossom, exhibits a most beautiful spectacle. Its stem generally rises to the heighth of twenty feet, and branches out on every side towards the summit, so as to form a kind of pyramid. The slender shoots are adorned with flowers of greenish yellow, which protrude in thick clusters at every joint, and which retain their beauty a long time. A succession of fresh flowers is produced for nearly three months, in favourable seasons. The popular opinion, that the aloe flowers but once in a century, is without foundation. The leaves of the American aloe are five or six feet long, from six to nine inches broad, and three or four feet thick. They are manufactured into cordage and packing cloths.

Fig-tree. Class twenty-three; Polygamia. This is a tree of moderate size, whose leaves are large, succulent, and smooth, irregularly divided into five lobes, standing on long footstalks. The flowers are, at first, concealed from view, until the ripening, or bursting, of the fruit, which includes the flower, and does not merely hold it in a calix. The fruit, which is very wholesome, is dried by the heat of the sun, or an oven, and imported into Britain from the south of Europe and Asia Minor.

Flax. This is a valuable annual plant, which is supposed to have come originally from Egypt. It now grows wild in the south of England, and is very extensively cultivated in the British European and North American dominions. From its fibres is manufactured that useful part of clothing, linen. The oil which is expressed from its seeds, named linseed oil, is applied to medical and other purposes. It is assigned to the class Pentandria. The branches are simple, erect, and terminated by flowers, which are single, and of a light blue colour. The leaves are lance-shaped. The calyx is divided into five segments. The corolla is composed of five petals.

Nettle. The nettle is a well known plant, whose stem is erect, quadrangular, and defended with hairs. The leaves are large, heart-shaped, deeply serrated, veined, wrinkled, covered with sharp prickles, standing in pairs, on long foot-stalks. The prickles, or stings on the leaves, when examined by the microscope, appear to be fine tapering tubes, perforated at their points, and having small bags at their bases. When the stings are pressed by any part of the human body, they pierce the skin, and the same pressure forces up from the bags a minute drop of an acrimonious fluid, which, entering the wound, excites painful inflammation. The stalks, like flax or hemp, may be manufactured into cordage, nets, cloth, or paper. This use is made of them in some parts of Russia. The roots yield a beautiful yellow dye. The nettle possesses, also, some medical virtues. It belongs to class twenty-one, Monœcia.

The Oak. This valuable tree is a native of Britain. It frequently grows to a very large size, extending its huge branches to a great distance from the trunk. The leaves are of a peculiar form, being deeply cut in notches, and shaped into blunt lobes, standing upon short footstalks. The flowers are inconspicuous, but the fruit becomes conspicuous, being fixed in a kind of cup. These fruits are called acorns, and probably constituted one of the first articles of human food. The wood of this tree is highly valued for its durability, and is applied to ship-building, and many other useful purposes. The bark is used for dyeing and tanning.

It belongs to class twenty-one, Monœcia.

QUESTIONS.

In what manner are plants produced, and how do they grow? What are grafting and budding?

CHAP. XXVII.

AGRICULTURE. — HORTICULTURE.

With botany are closely connected agriculture and horticulture.

Agriculture, in general, may be defined to be the art of causing the earth to produce in as large quantities as possible, and of the best quality, those vegetables which are necessary to the subsistence, or useful for the accommodation of mankind.

Horticulture is the art of producing in smaller quantities, the more delicate vegetables, valued rather as objects of luxury, than requisite articles of food. In civilized societies, agriculture becomes a separate occupation, and those who are engaged in it, are styled agriculturists, farmers, or husbandmen.

Agriculture may be considered likewise, as including the rearing of cattle, and other animals used as food, or necessary to the accomplishment of its purposes.

It is, therefore, an art which takes a very extensive range, and comprehends a variety of objects, soil, seasons, plants, animals, so far as they are connected with the subsistence of the human race.

The importance of agriculture has been admitted by all associated bodies of men, from the beginning of the world. The Chaldeans, the Egyptians, the Persians, the Phœnicians, the Athenians and other Greeks, the Romans, all acknowledged the value of this art, and practised it in various degrees; and, among modern nations, it has been gradually rising in consideration. At present, very great attention is paid to this art, and it is probable that, in process of time, the inhabitants of the earth will produce from its surface, quantities of food far greater than they do at present. Some vegetables afford subsistence by means of fruit which grows upon them, which is brought to maturity in the air, at the summit of their stems; others produce roots that come to maturity under the ground, and which yield wholesome nourishment. But experience has taught men not to rely entirely, or principally on fruit-bearing trees, for food. They come to their perfection slowly, and they are liable to be destroyed by accident or intentional violence. It is difficult to preserve their fruits, and to make from them preparations capable of being kept for any length of time. Men have, consequently, trusted rather to the cultivation of plants of annual growth, and to their seed or grain, or roots, for permanent subsistence.

Of such plants, wheat has been accounted most valuable, probably from the facility of producing a fermentation of its flour, which renders it capable of becoming a lighter and more convenient kind of bread than the flour of any other grain.

Wheaten bread constituted the chief food of the Roman soldiers, and to its use is attributed, in part, the extraordinary strength they appear to have possessed. For the same purpose, oats and barley are applied with great efficacy.

Of the roots which are used to afford subsistence to man, the potatoe is the most universal. It appears, indeed, that the cossava root, in those countries where the plant grows, affords abundant nourishment. Carrots, parsnips, and turnips, are now never used as a sole nutriment, but rather as accompaniments to animal food. Roots, however, are not easily preserveable. In winter, they are destroyed by frost, and in summer, by heat, which causes them to vegetate and corrupt.

Rice is a grain which affords sustenance to vast multitudes of the human race, throughout the greater part of Asia, and many parts of Africa.

Agriculture has likewise for its object, the abundant production of nutritious food for cattle; and consequently, considers the wholesomeness of different vegetables, with regard to health, strength, and speedy fattening; the quantity which any particular extent of ground may be made to yield; the quantity necessary to feed the different kinds of cattle; the labour and method of cultivating the soil; and the soil those vegetables require to be brought to perfection. To the purposes of feeding and fattening cattle, are applied various kinds of grasses, cabbages, turnips, carrots, potatoes, and many sorts of herbs and plants. Grass is cut and dried for the winter stock of food, and is then called hay.

The looser and more divisible earth which covers the greater portion of the surface of the globe, is named soil. This is considered by agriculturists, as divided into four kinds, which are in general mixed with one another, but receive their common names from the kind that predominates, or is most abundant. These are, sand, clay, chalk, and garden mould. Of these soils, sand does not sufficiently retain water for the flourishing growth of vegetables; and clay will not suffer their roots to expand with freedom; chalk, or calcareous soil, is not adapted for raising useful plants, without intermingling with it other substances. Garden mould is the most proper of all kinds of soil, for rearing those plants which are accounted the most valuable in our climate. In proper circumstances, that is, with a due degree of heat and moisture, it never fails to afford an abundant crop, and a rich return for the labour of man. But as this kind of soil is not every where found, and it cannot be relied upon as permanent where it does prevail, for by incessant demands it is exhausted, its fertile qualities are weakened, if not lost, and thus it becomes unfit for the purposes of agriculture. It is, therefore, necessary to refresh and quicken, and renew its powers by the admixture of other substances. This process is called manuring, and such substances added to soil, are called manures. Nature renews the productiveness of soils, or prevents their exhaustion by the decomposition of trees, plants, and other vegetables, when they die. The decomposition of vegetables by which they are made to yield their carbonaceous matter, of which a considerable quantity is always found in rich garden mould, and their other component parts, is the surest method of forming or renewing soil. For the accomplishment of this purpose, various means and agents are employed. To restore an exhausted soil, the dung of animals, and putrefied substances, are applied. For quickening the productive powers of the soil, lime, either pure, or combined with clay under the form of marl, is used. Paring the surface, burning it, and scattering the ashes, is another mode of manuring. Turning up the soil, and exposing its internal parts to the action of the atmospheric air; pulverizing it, by introducing into the soil vegetables, whose roots swell, penetrate, and extend themselves in various directions, are likewise employed for rendering it a proper receptacle for seeds of beneficial plants. Some vegetables appear to enrich the soil.

The manures used by agriculturists may be classed under the respective heads of, manures of the animal kind; manures of the vegetable kind; manures of the earth, or fossil kind; manures of the saline kind; manures of the mixed, or compost kind. Animal manures are, all sorts of animal dung, and bones, horns, hoofs, and other similar substances, and seem to produce the most rapid and luxuriant effects.

Vegetable manures are, all the parts of plants and herbs when decomposed by fermentation and putrefaction. Trunks, stems, leaves, fruit, are all conducive to this end. Vegetable manures are more gradual and lasting in their fertilising operations.

Earthy and fossilic manures are, lime, calcareous earths, marl, chalk, lime-stone, gravel, shells, and sand.

Saline manures are, the refuse of various manufactures, such as bleaching and soap-boiling, the ashes of different green vegetable matters, wood, pit-coal, peat, soot, and sea-salt.

Mixed, or compost manures; straw, litter, the diversified contents of farm yards mingled together, sweepings of streets.

Agriculture attends likewise to the clearing of the ground from weeds, which would choke the rising plants, or take to themselves those substances which are necessary to the growth of the more salutary, but, perhaps, less vigorous vegetables. For this purpose, it considers the nature of the different kinds of weeds, and the most efficacious methods of destroying them. The diseases of plants, and the insects which injure them, with the best means of curing the former, and checking the ravages of the latter, are objects of the agriculturist's care and attention.

The different modes of preparing the ground to receive the seed, and of committing the seed to the ground, and all other methods of propagating useful vegetables, claim the attention of the farmer.

The practice of agriculture may be considered as divided into three parts.

The cultivation of vegetable food for men and animals.

The cultivation of vegetables which are articles of commerce, such as hemp, flax, and other plants of that nature.

The rearing and management of animals, which is termed grazing.

Under the head of preparing ground, are consequently included the removal of stone, and the draining of bogs, morasses, and other wet lands.

QUESTIONS.

What is agriculture? What is horticulture? Has agriculture been in repute among different nations? Is fruit or grain most relied upon for the affording of food to man and beast? Which is accounted the most valuable grain? What grains and roots are principally cultivated for the food of men and cattle? What is soil, and how is it considered by agriculturists as divided? What is manuring ground? What are the chief substances used for manuring the earth? What are the principal modes of preparing the earth to receive seed? What other objects employ the attention of the husbandman? How is the practice of agriculture divided.

CHAP. XXVIII.

INSTRUMENTS OF HUSBANDRY.—HORTICULTURE.

Of the instruments of agriculture and of tillage, or preparing ground for seed, the first in importance is the plough.

The plough is a machine for turning up the soil, by the aid of cattle; contrived to save the time, labour, and expence, which, without this instrument, must have been employed in digging the ground, and fitting it for receiving all sorts of seed.

The plough performs its task of turning up the earth, not by digging, but by being drawn along. Its action is not intended to reduce the ground to that friable or powdered and uniform state into which it is brought by the spade; but into such a state as that the ordinary operation of the atmospheric air and rains, may complete the business.

The general form of the body of the plough is that of a wedge, having the lower corner of its edge considerably more advanced than the upper. The bottom approaches to a triangular form; the surface is of a complicated shape, generally hollow. The back is usually called by the ploughmen the land-side, and the base is named the sole. The other parts of the plough are the soc and coulter, to rip and cut; the mould board to turn over the earth; the heel and head, the sheath, the stilt, or handle. The plough is drawn by horses or oxen; while the ploughman guides and directs its movement by the handle. The coulter performs the first office of ploughing by making a perpendicular cut in the ground. The soc following, introduces its edge under the divided sod, and lifts it up. Then comes the mouldboard, pushes it aside, and gradually turns it over as far as necessary.

Great improvements have been made in this machine; and ploughs have been constructed adapted to different soils, and various purposes. The chain plough, by diminishing the friction, has diminished the necessity of a great number to draw it. The paring-plough pares the surface of the ground, in order to be burnt for manure. The drill-plough plants, or sows, as well as turns up the ground.

The sward cutter, is a machine used to prepare old grass ground for the plough.

The cultivator is an instrument employed to break and pulverize hard, tenacious soils, which have been once ploughed, in a more complete and rapid manner than can be accomplished by any other instrument.

The harrow is a machine that breaks the clods, and covers the seed, when cast into the ground.

The brake is a large and weighty harrow, the purpose of which is, to reduce a stubborn soil, upon which a common harrow would make but little impression.

The roller is an instrument of great use in husbandry. It is a cylinder of stone, cast-iron, or wood, with shafts for two horses a breast. Wheat, barley, oats, turnips, and flax, should be rolled at their proper seasons. The operation presses the seed into the earth; covers roots which may be above ground; renders a loose soil more compact and solid; keeps in moisture, and consequently prevents the land from growing very dry, to any depth.

The fallow-cleansing machine, intended, as its name bespeaks, to clear fallows from weeds, and other mischievous substances.

The universal sowing machine, which is made to be worked by the hand, drawn by a horse, or fixed to a plough.

Horticulture, or gardening, was probably one of the first arts which succeeded to that of building houses. Culinary and medicinal herbs must have been objects of great importance in the early ages of society; and it must therefore have been found convenient to have them within reach at all times, to obviate the necessity of seeking for them in the fields and woods. Thus history informs us, that gardens were objects of attention among all civilised people.

The Almighty placed infant man in a garden. The gardens of Alcinous, celebrated by Homer; the gardens of Solomon, the wealthy, powerful, and wise monarch of Israel; the hanging gardens of Babylon; the gardens of the Persian kings; those of Lucullus, and other luxurious Romans; all attest the early and attentive cultivation of this art. Until comparatively modern times, a false unnatural taste prevailed in this art. Gardens were laid out with great formality, and quite opposite to the lovely pattern which nature set before the eye of man. Straight walks; straight canals; beds of flowers in fantastic, but stiff forms; trees cropped, to imitate objects quite foreign to them; artificial fountains and water-works; multitudes of statues crowded together; flights of steps; magnificent balustrades; Chinese railings; vases, and handsome flower-pots, contradicted every principle of good taste and judgment. But now, gardens are landscapes in miniature. They imitate, instead of opposing nature. The waving lines of beauty delight the eye. Shrubs and trees are no longer diverted from their natural bent by the merciless sheers. The rivulets flow in winding streams. The flowers are scattered in wild profusion, or grouped so as to charm the eye by the pleasing contrast and intermixture of colours. Horticulture is now brought to such perfection, as to be justly ranked among the liberal arts. The general materials for the pleasure-garden may be regarded as either natural or fictitious. The natural materials are, ground; whether lawn, heights, valley, plain, or swelling. Wood; comprehending grove, clump, shrubbery, or single trees. Water; either lake or running stream. Rocks, sloping, or precipitous. The factitious accompaniments are fences, walks, roads, bridges, seats, canals, fountains, statues.

It is the gardener's business to adapt plants, and shrubs, and trees, to their proper soils and situations; to study picturesque beauty, character, general arrangement, and embellishments which o'erstep not the modesty of nature. In the kitchen-garden, it is the work of horticulture to produce the different vegetables at their proper seasons, and in perfection; to rear foreign plants and fruit trees, and to quicken the ripening of fruits by forcing walls, and hot-houses, heated by flues, and by hot-beds; by green-houses to protect exotics from the inclemencies of our climate.

Its principal instruments are, various kinds of spades; hoes, for cleansing the ground from weeds; watering machines; rollers, for grass and gravel; sheers; rakes; trowels.

QUESTIONS.

What is the plough? What are its advantages? What is the cultivator? What is the brake? The harrow? The roller? The fallow-cleansing machine? The universal sowing-machine? Has horticulture been long attended to by mankind? What was the old style of gardening? What is the modern style? What are the chief objects of horticulture? What are the principal instruments of horticulture?

CHAP. XXIX.

ZOOLOGY.

VARIOUS PARTS OF ANIMALS.

The properties common to animals and vegetables are more numerous than the essential distinctions which exist between them. Plants are covered with a bark, as animals are with a skin. The leaves of plants fall off at certain seasons; so do the hair and feathers of many animal bodies, and the skins and shells of others. The circulation of the sap in vegetables, like that of the blood in animals, diffuses vigour and nourishment. Many vegetables are endowed with the power of organic motion; though they do not possess the loco-motive power. This is the case, likewise, with the various kinds of Zoophites, with the oyster, and some other shell fish. The mimosa, called the sensitive plant, shrinks from the touch. The Dronæa Muscipula, or Venus's fly-trap, shuts its leaves, the instant a fly pitches upon them.

The Hedysarum Gyrans, a product of Bengal, exhibits the appearance of voluntary motion; for two small leaflets, situated on each side of the footstalk, alternately meet and separate, during the greatest part of the day. Some vegetables resemble animals in form. The flower of one of the Orchis tribe is like the bee, another like the wasp, and a third like the spider: while many insects of the Mantis tribe are so like clusters of leaves, that they are called walking leaves. The sea anemone, when perfectly expanded, bears so strong a resemblance to a flower, as that it was long accounted to be a vegetable.

The first step which nature takes towards the communication of the faculty of voluntary motion, seems to constitute the connection between the vegetable and animal kingdoms. We take, for example, the oyster, and other shell fishes, that have not the power of moving from one place to another, with the different tribes of Zoophites.

Animals may be defined to be, organized bodies, endowed with the faculties of sensation and voluntary motion.

Vegetables, being attached to the earth, collect its nutritive substances by their roots. On the contrary, animals have an internal cavity, in which they deposit the substances destined for their nourishment. The inward surfaces of this cavity are furnished with numerous absorbing pores, or vessels, which may be regarded as so many internal roots. In many animals, the magnitude of these cavities enables them to introduce into them solid substances. They are accordingly provided with instruments for breaking, and liquors for dissolving, such substances. So that animal nutrition does not begin immediately upon the reception of the aliments which they derive from the earth, or the atmosphere. It is necessarily preceded by a number of preparatory operations, the whole of which constitutes animal digestion.

The organization of animals is far more complicated than that of vegetables, and the elementary principles which enter into their composition are more numerous.

The soft parts of animals are composed principally of carbon, hydrogen, azote, and oxygen; while the bones are constituted of calcareous earth and phosphoric acid, together with a very small portion of iron and of neutral salts, combined with muriatic, phosphoric, and carbonic acids. These elementary materials are thrown into new combinations and arrangements by the operation of heat. The hydrogen and oxygen, uniting, form water; the carbon and hydrogen produce oil; the hydrogen and azote, volatile alkali; the oxygen and carbon, carbonic acid.

By being boiled in water, the soft part of an animal body is gradually dissolved, and a matter is extracted, which forms, when cold, a solid but tremulous mass, called jelly. When the watery particles are nearly evaporated from this, it becomes glue. Glues differ from one another in consistence, taste, odour, and solubility.

Blood is a fluid essential to animal life, but which varies considerably in different species of animals. In man, and other large animals, its colour is red, but in some smaller animals it is almost colourless. But the most remarkable difference in the blood of animals, is with respect to its temperature. The blood of man, of quadrupeds, and of birds, is warmer than the air in which they live; from which circumstance they are called warm-blooded animals. In fishes and reptiles the blood is of nearly the same temperature with the medium they inhabit; and they are, therefore, called cold-blooded animals.

Blood, when first taken from a vein, exhibits the appearance of a uniform red fluid. It then consolidates into one mass, from which, in a short time, a yellowish watery liquor begins to separate, while the red mass, contracting itself, expels the watery fluid from its pores, and increases in solidity.

The solid part is called the crassamentum, and the liquid which surrounds it, the serum. The red part of blood is found to contain a certain portion of iron, and therefore the red colour of the blood is generally attributed to the presence of this metal.

The principal parts and organs of animal bodies, in general, are, the medullary substance, nerves, muscles, bones, cartilages, tendons, ligaments, nervous system, organs of nutrition, blood-vessels, glands, lymphatics, and organs of respiration.

The medullary substance is that organ in which resides the faculty of sensation. In all animals, in which this is distinguishable, it consists of filaments, proceeding from central points, and thence distributing themselves over most parts of the body, where it takes the name of nerves.

The nerves are those filaments which, having their root in the medullary substance, extend thence to the various parts of the body. A nerve, when touched by a foreign body, causes a sensation of pleasure or pain.

The nerves, by which we discern external objects, are provided with organs at their extremities, by which that purpose is curiously and admirably answered.

These nerves approach one another, and unite in bundles, which contain proportionably more filaments, as they are traced nearer to their common origin, the spinal marrow, the anterior extremity of which is joined to the brain, as a root. The brain is a medullary mass of greater or less magnitude, and of different form in different animals.

Muscles are bundles of fleshy fibres, the extremities of which are attached to the moveable parts of the animal body. By means of the muscles, all the external motions of the body and the members are produced.

Bones are those hard parts of the body to which the muscles are fastened, and which are covered by them. The whole system of bones is called the skeleton.

When the hard parts of the animal body are not covered by the muscles, but inclose them, they are, in that case, denominated shell, crust, or scale. But in both instances the hard parts always inclose the inward parts of the body, and determine its exterior figure.

Cartilages are firm, smooth, elastic bodies, which cover the ends of the bones.

Tendons are tough cords, by which muscles are attached to bones.

Ligaments are strong fibres, which connect bones with one another.

The organs of nutrition are, the mouth, into which the food is taken, and, when solid, is masticated, and moistened by dissolving liquids. A tube, called the alimentary canal, then receives the nourishing substance so prepared, and passes it into a receptacle, called the stomach.. The inner coats of the stomach yield a liquid, called the gastric juice, which reduces the food into a homogeneous pulp. The remaining parts of the alimentary canal, for the stomach may be considered as an extension of that canal, are called bowels, or intestines. In these the aliments undergo the change which fits them for nutrition.

Blood-vessels are flexible tubes which convey the blood from, and to, the heart, its grand receptacle. Those which convey the blood from the heart are called arteries; those which convey the blood to the heart are named veins, and they are furnished with valves, all opening in the direction in which the blood flows through them.

Glands are organs, destined for the purpose of secretion; that is, for forming various liquids necessary to various operations in the animal frame. The most remarkable of them are the pancreas, and the liver, which secretes the bile.

Lymphatics are small vessels which, in animals that have a circulation of the blood, absorb the nutritive parts of the food during the act of digestion, and conduct them into the general system of nutritive vessels.

The organs of respiration answer the purpose of bringing the blood into contact with the atmospherical air before it enters into the arterial system. In animals, which have blood-vessels, the organs of respiration consist in a ramification of those vessels, increasing their surface to such a degree that almost all parts of the blood contained in them are separated, by a thin pellicle only, from the element in which the animal exists. This ramification takes place on the surface of certain folds, in aquatic animals, and on that of certain cells in animals living in air. In the first case, the organ of respiration is styled Branchiæ; in the second, lungs. In animals that have no blood-vessels, the air reaches all parts of the body, and acts upon the nutritive fluid, at the instant when that fluid combines with the body, which it is intended to nourish.

There are muscular organs adapted to each of these modes of respiring, destined to attract or impel the surrounding fluid towards the place where it has to act upon the blood. This office is performed by the ribs, the diaphragm, the muscles of the abdomen, the flaps of the gills, or other parts, according to the respective natures of the animals.

Voice is sound produced by air, in animals which respire by cellular lungs. In such only can air be employed in the formation of the voice, because in them only it passes through a single and lengthened tube, which is called the windpipe. In one or two parts of this tube there are membranes susceptible of tension, which vibrate when the air acts upon them, and thereby produce the various sounds which compose the voice. Animals that have no voice, properly so called, are not, however, devoid of the power of making certain sounds, but they do so by other means.

The instrument, or organ, of the voice is named the Larynx. The expulsion of air through this organ is the immediate cause of voice.

The Senses. Feeling, Sight, Hearing, Taste, Smell.

The only sense which is found in all animals, without exception, and which is diffused over almost the whole surface of their bodies, is that of feeling. The other senses seem to be only modifications of feeling, but are capable of receiving more delicate impressions.

The sense of seeing resides in the eye, that of hearing in the ear, that of smelling is attached to membranes, situated within the nose; that of tasting is seated on the surface of the tongue. These senses are always placed in the same extremity of the body with the brain, and which is called the head.

QUESTIONS.

Wherein consists the similarity between plants and animals? What seems to constitute the connection between the animal and vegetable kingdoms? What may animals be defined to be? How do animals receive nourishment? Of what are the soft parts of animals composed? Of what substances are the bones constituted? What are jelly and glue? What is blood? What is the difference between cold-blooded and warm-blooded animals? What are the principal parts and organs of animal bodies in general? What is the medullary substance? What are nerves? Muscles? Bones? The skeleton? Cartilages? Ligaments? Organs of nutrition? Blood-vessels? Glands? Lymphatics? Organs of respiration? What is voice? What is the larynx? What are the senses?

CHAP. XXX.

ZOOLOGY — continued.

CLASSIFICATION OF ANIMALS.

The most ancient known division of the animal world, is that of Aristotle, which classes animals under the terms viviparous; that is, producing living and perfectly-formed young: and oviparous; that is producing eggs, from which the young afterwards come forth. This division, though very imperfect, continued in use, with some modifications, till towards the close of the 17th century, when Ray formed a new classification of animals, founded principally on the structure and nature of the heart and lungs, in the different tribes.

Linnæus, the celebrated Swedish naturalist, taking Ray's classification for a basis, framed a new division of the animal kingdom into three grand classes.

The first of these divisions comprehends those animals which have warm, red blood, and a heart consisting of two cavities, or ventricles. The second includes those animals whose blood is cold, yet red, and whose heart has but one cavity, or ventricle. Under the third division are ranged those animals whose blood is colourless, or pale, and cold; and whose heart has only one ventricle.

The secondary, or more particular Linnæan distribution of animals, has six divisions.

First, mammalia; animals who suckle their young. To this class belong man, the ape tribe, whales, bats, and many others. Animals of this class have three kinds of teeth; in front, cutting teeth, called incisores; on each side of them, sharp, long teeth, called dentes caninæ, or canine teeth; and lastly grinders, dentes molares, having broad, angular tops, adapted to grind substances which have been previously cut and separated by the incisores and canine teeth.

The mammalia possess the senses of sight, hearing, tasting, smelling, and feeling. To this genus is assigned, also, a gigantic quadruped not known to exist at present, of which a fossil skeleton was found in South America. It has been described under the name of Megatherium, and appears more nearly allied to the sloths, than to any other of the mammalia.

Naturalists are in doubt whether they ought to add to this division an extraordinary animal discovered in New South Wales, called the duck-bill, or platyplus. This creature is a quadruped with the bill, or beak, resembling that of the duck. It has no teeth, and the tongue is situated very far back in the mouth. The feet are webbed, and furnished with five sharp and strong claws. Besides these claws, the male has on each foot a kind of crooked spur, like that of a cock. The body is broad and rather flattened. The eyes are so small and so deeply sunk in the head, as not to be distinctly visible, without close inspection. The tail is broad, short, and pointed. This animal is covered with strong, but soft and glossy hair, of a deep iron-grey colour. It inhabits fresh-water lakes, and is supposed to feed on worms, water insects, and plants. It is obliged to rise to the surface of the water at intervals, in order to breathe, and is thought to burrow at a considerable depth in the banks. No organs of suckling have been found, as yet, in the female, and the animal is therefore supposed to be oviparous, bearing internal eggs, from which the young are hatched before their final expulsion.

The second class of Linnæus comprehends the various tribes of birds.

The third, the amphibia, comprizing the lizard, the tortoise, the frog, and the serpent tribes.

The fourth includes the fishes.

The fifth, insects.

The sixth, the mollusca, or soft-bodied animals.

The class Mammalia is divided into seven orders:

First, Primates; comprehending man, apes, lemurs, and bats.

Second, Bruta; comprehending the animals which are referred to the genera of sloth, armadillo, pangolin, and the ant-bear.

Third, Feræ. This order includes the beasts of prey, having teeth evidently calculated for feeding on animal food, and claws extremely sharp. The genera of this order are the dog, including the hyæna, the wolf, the fox, the jackall, and all the varieties of dogs. The cat, comprehending the lion, the tiger, the leopard, the panther, the jaguar, and all the cat kind. The weasel tribe, whose general characters are, slenderness and length of body, sharpened face, short legs and long tail. With these is ranked the ichneumon, which was highly esteemed by the ancient Egyptians for its propensity to destroy the eggs of the crocodile, and various noxious animals. To this genus belong also the bear, the opossum, the Kangaroo, the shrew, and the hedge-hog.

Fourth, Glires, or Sleepers. To this order belong the porcupine, the beaver, the mouse and rat tribe, the Guinea pig, the squirrel, the rabbit, the dormouse, the jerboa.

Fifth, Pecora; comprizing all cattle, such as oxen, sheep, goats, the camel; the giraffe; the deer tribe, the antelope, the elephant. In some parts of North America are found fossil bones, bearing a general resemblance to those of the elephant. The name Mammoth is given to the animal of whom they are the remains. By some it has been considered as a species of elephant, while others imagine it to be of a different species, now extinct. The dentes molares are like those of carniverous, or flesh-eating animals. It is supposed that this animal had tusks like the elephant's, with a similar proboscis. One distinguishing character of this tribe is, the power of ruminating; that is, of throwing up into the mouth at intervals a portion of the food that has been hastily swallowed, to undergo a more complete grinding by the teeth.

Sixth, Belluæ. This order includes the horse, the ass, the rhinoceros, the hippopotamus, the tapir, and the hog.

Seventh, Pinnata; comprehending the seal, the walrus, the manatus. To this order belong, likewise, the varieties of the whale tribe; the common northern whale, the largest of known animals; the rostrated, or taper-snouted whale; the whales which afford the substances called spirmaceti and ambergris; the dolphin, the porpoise, the narwhal, or sword-fish, and the grampus. The whale, cete, is now assigned a separate rank.

Birds are far more numerous than quadrupeds, and differ from them materially in form and make. Their skeleton, or bony frame, is much lighter, and calculated for flying. The spine is immovable, but the neck long and flexible. The breast bone is very large, with a prominence down the middle, adapted to the fastening of strong muscles. All their bones are lighter, or have larger cavities than those of quadrupeds.

The class of birds is divided by Linnæus into six orders.

First, Accipitres, or birds of prey. This order comprehends eagles, vultures, hawks, owls, and shrikes, or butcher birds. Among the vultures is ranked the condor of South America, the largest of birds possessing the power of flying.

Second, Picæ; including all the birds of the crow and jay kinds, parrots, woodpeckers, kingfishers, and the beautiful humming bird.

Third, Passeres; which comprises pigeons, thrushes, larks, all the finches, and small birds in general.

Fourth, Gallinæ; such as are more or less allied to the common fowl; the pheasant, the partridge, the peacock.

Fifth, Grallæ, or Waders. This comprehends the heron, the curlew, the plover, and the numerous birds which have very long legs, and chiefly frequent marshy places.

Sixth, the Anseres, or web-footed birds; as the swan, the goose, and duck tribe, the gull and the penguin.

The ostrich, the giant of the bird nation, the cassowary and the bustard, are by some naturalists ranked among the Gallinæ, and by others, among the Grallæ. In this last order is included the ibis, highly esteemed in ancient times as the great distroyer of serpents, like the secretary falcon of modern days. Two new classes, that of Pigeons and Struthio, are added lately.

The name Amphibia is given by Linnæus to such animals as have cold blood, and live partly on land and partly in the water. They do not chew their food, but swallow it whole; and have the power of living a long time without sustenance. Most of the amphibia are oviparous, or ovi-viviparous, and possess a high degree of the reproductive faculty, so that when their feet, tail, or any other members are lost by any accident, others soon grow in their place. In general, they are of mild and gentle disposition, though some among them are fierce and rapacious. In cold and in temperate climates, nearly all the amphibia continue in a torpid state during the winter.

They are divided into two great orders, Reptiles and Serpents. These orders have several subdivisions. To the lizard tribe belong the formidable crocodile and aligator; in the serpent tribe are the huge boa constrictor, the dangerous rattlesnake, and the hooded snake, or cobra di capello.

Fishes are destined by the Universal Creator to inhabit the waters and people the vast extent of ocean, and their figure and organs are admirably adapted to that situation. Their bodies are generally so shaped as to enable them to move rapidly through the resisting medium which is their abode. They are commonly covered with scales, which preserve them from being injured by the pressure of the water. They breathe by means of organs placed on each side of their necks, called gills, somewhat like combs. In this operation the mouth is filled with water, which is driven backwards with so much force as to open a kind of lap covering the gills, and to burst forth behind. The greater part of the air contained in the water is separated from it during its passage through the gills, and carried into the body, to perform its part in the animal economy. Fishes are of nearly the same specific gravity as water, and swim by means of their fins and tails.

A curious organ, named the air-bladder, enables some fishes to encrease or diminish the specific gravity of their bodies, so as to sink or rise at pleasure. The teeth of fishes, which are sharp and commonly immoveable, are in general situated in the jaws, like those of most other animals; though in some they are placed in the palate, or in the throat, lying flat, and erected when the fish is about to bite; as are those of that dreadful sea monster, the shark. They have nostrils and olfactory nerves, and therefore it is probable that they have the sense of smelling. The sight of fishes is supposed to be the strongest of their senses. Their food is almost universally in their own element. Some feed on aquatic plants, but by far the greater number are carniverous.

Fishes are mostly oviparous; though some few, such as the eel, produce their young formed and alive. They live much longer than most other animals. This class is divided into five orders.

First, the Apodal; including such as have no ventral fins.

Second, the Jugular; those which have the ventral fins more forward than the pectoral fins.

Third, the Thoracic; consisting of such fishes as have the ventral fins immediately beneath the pectoral fins.

Fourth, the Abdominal, including those whose ventral fins are situated behind the pectoral fins.

The fifth division includes the Cartilaginous fishes. This tribe differs from all the others, in having a cartilaginous, instead of a bony, skeleton, and in being destitute of ribs.

QUESTIONS.

What was the most ancient known division of the animal world? Upon what was the classification proposed by the naturalist Ray founded? What general division of the animal kingdom did Linnæus adopt? What are the subdivisions of the Linnæan classification? Into how many orders is the class Mammalia divided; and which are the principal animals belonging to each of those orders? What are the general characteristics of the bird tribe, and into how many orders is that tribe of animals divided? What birds belong to those respective orders? To what animals does Linnæus give the name Amphibia? What are the general characteristics of the Amphibia? How are the Amphibia divided; and what animals belong to their respective divisions? What are the general characteristics of fishes? How is this tribe of animals divided?

CHAP. XXXI.

ZOOLOGY—continued.

The characters by which insects are distinguished from other animals are the following.

First; they are furnished with several feet; never fewer than six, and sometimes a much greater number.

Secondly; their flesh is attached to the internal surface of their skin, which is generally of a tough or strong substance, and in many of them, hard and horny.

Thirdly; insects breathe, not by lungs or gills, but by a sort of spiracles or breathing holes, situated, at certain distances, along each side of the body.

Lastly; their head is generally furnished with a peculiar pair of processes, called Antennæ, or jointed horns, which are very various in the different tribes.

The mode of production of insects, also, is different from that of other animals. Their first appearance, commonly, is in that of an egg. From this, they are hatched into another state, named the larva, which is different as to figure and power of motion, in different insects. In the moth and butterfly tribe, it is that of a worm with many joints and legs, and is called caterpillar.

In the beetle tribe it is of thick heavy form. In the locust or grasshopper tribe it does not differ much from the complete insect except in not being furnished with wings. In the fly and the bee tribe it is of an oblong oval form without feet; known by the name of maggot. In this state of their being, insects are the most voracious. From the Larva state, insects pass into that of the chrysalis or pupa, by divesting themselves of their external skin, and in this condition, likewise, insects differ greatly from one another. In most of the beetle tribe, the chrysalis is furnished with short legs, so as to be capable of a degree of loco-motion. In most of the fly tribe, it is perfectly oval without any apparent motion, or distinction of parts. In that of the butterfly it is destitute of all appearance of limbs, and has no other motion than a mere bending to one side, when touched.

From the chrysalis, or pupa state, the insect finally emerges in its perfect form, which is no more changed, and in which no farther growth takes place. Some insects undergo no such changes but are hatched from the egg complete in all their parts, and only cast their skin, from time to time, till they acquire their full size. In the greater part of insects, the head is distinctly separate from the breast, and the breast from the body. The limbs of insects are generally divided into a regular thigh, leg, and foot; which latter generally consists of several joints, and in most tribes, is terminated by a pair of curved claws. In some, as the beetle family, the mouth is formed for gnawing or breaking their food. The brain is very small, but from it extends a kind of pulpy cord, like the spinal marrow, which, ramifying into branches or divisions, is conducted to the different parts of the body, and forms the nervous system of insects. The eyes differ in the different tribes; though most of them have two only. The outward coat or surface of the eye is composed of numerous minute hexagonal convexities, like convex lenses. The eyes of the common dragon-fly are composed of no fewer than 25,000 of these diminutive lenses. Spiders have from six to eight eyes, of a simple structure, and placed at a considerable distance from one another. Besides the common eyes on each side of the head, some insects have two or three separate eyes, situated on the summit of their heads. The muscles of insects are more numerous, more irritable, and comparatively more powerful than those of larger animals; thus the flea and the grasshopper are capable of springing to a much greater distance than quadrupeds relatively to their respective sizes. Insects do not breathe by lungs, but by means of numerous pores, generally situated on each side of the body, and which are continued into numerous branches. It is not absolutely determined whether there be any circulation of blood in insects.

Linnæus distributes all insects into seven orders.

First, Coleoptera or sheathed winged insects. This order comprehends all the beetle family. In these animals the real or proper wings are of a membraneous nature, and when not in use, are curiously folded up in strong horny sheaths.

Second, Hemiptera, or half-winged insects. In this order, the wings are often of large size and plaited longitudinally like a fan. The sheaths are of a tough leathery nature. This order comprehends all the insects of the locust tribe; the cock-roaches; the lantern flies; the cicadæ.

Third, Lepidoptera, or scaly-winged insects. This order comprehends all the moth and butterfly tribe, or the papilionaceous insects.

Fourth, Neuroptera, or nerve-winged insects. These have four large wings, furnished with conspicuous nerves and fibres, dispersed over the whole wing. To this order belong the dragon flies; and the curious ephemera, which after having passed three years in its larva state, lives but six hours in its complete form.

Fifth, Hymenoptera, including the insects having four membraneous wings. This order includes the wasp and bee tribes, and the ichneumons who deposit their eggs in the bodies of other living animals, generally in those of caterpillars.

Sixth, Diptera, consisting of insects that have only two wings. This includes the whole race of flies, as well as gnats.

Seventh, Aptera, comprehending those insects which have no wings. This includes spiders, scorpions, scolopendra, monoculi, mites. Lobsters and crabs, are assigned to this order by Linnæus, but they are dismissed from this class by other writers. Crabs and lobsters cast their skins annually. Their bodies shrink before the season of change,. in such a manner, that they are enabled to draw their limbs from the shells easily. The crab possesses the extraordinary power of casting off any limb that happens to be maimed or bruised and of gradually protruding a new limb.

Scorpions have oblong bodies, eight legs and two large claws in front; a long jointed tail, having at the tip, a crooked, sharp-pointed sting, at the base of which is a poisonous fluid, which the animal injects into the wound it makes with it. The spiders, some of which are very large, have also a venomous liquid in their fangs. They have eight legs and four or five small organs at the end of their bodies, through which they spin the threads of which their curious webs are constructed.

The Mollusca, or soft-bodied animals, are divided, by the Linnæan arrangement, into such as are destitute of a shelly covering, and such as have such a covering. Those which belong to the former class feed entirely on vegetables, and are produced from whitish, gelatinous eggs, deposited in shady situations, beneath the surface of the ground. Among the marine mollusca, many are of a phosphorescent nature, and appear luminous during the night. To this class belongs, also, the sepia, or cuttle-fish. This animal has a fleshy, long body, enveloped in a kind of sheath, reaching nearly to the head, which is furnished with very large eyes, and a horny beak, like that of the parrot. Round the base of the head extend eight long arms, and in some species, are two additional arms of a much greater length than the others. All these arms are set, with numerous round, concave cups on the inside, which, acting as suckers, adhere very strongly to whatsoever substance the animal chooses to attach himself. Some of these are so very large as to be extremely dangerous to men bathing, and even to persons in boats. The sepia has an internal pouch or receptacle filled with a very dark-coloured fluid, sometimes intensely black. This fluid, the creature can discharge at pleasure through an orifice situated at the base of the breast.

To this class belong also the various kinds of the medusa, known by the common name of the sea-blubber. These are animals of prey living on the smallest sorts of fishes and marine insects. Many of them are highly phosphorescent. Among these are classed likewise, the holuthuria physalis, resembling an oblong transparent bladder, of a pale purple colour, whose tentacula or feelers of a deep purple hang like streamers; the actinia, or sea-anemony; the asterias, or star-fish; the echinus, or sea-urchin.

The mollusca testacea, or soft-bodied animals with shells, are ranged in three divisions: univalves, those having one shell; bivalves, those having two shells; multivalves, those which have several parts or valves in their shelly covering. To these belong the various tribes of snails, the nautilus, the pearl muscle, the lipas or barnacle, and all the varieties of worms. Many of these latter, are inhabitants of living animal bodies. Of these, the genus named tœniae, or tape worm, is very numerous, and exhibits a great variety of appearance.

Those wonderful creatures which are distinguished by the term zoophytes, or plant-animals, and the microscopic animals, may be regarded as forming distinct classes. To the zoophytes belong, the hydra or polype; the varieties of coral; the madrepores. These are chiefly found on the coasts of the Indian islands, where they are so numerous as to form vast rocks; their animal inhabitants appearing to carry on the work of forming their hard coverings, by calcareous secretion, by instinct continuing their increase in such a manner, as to encircle a vast body of water, and thus form to themselves a smooth bay. Such a bay included between banks of these zoophytes becomes a receptacle for those fishes who delight in still waters; and the shallows made by them, form a quiet situation for mollusca and shell-fish of all kinds.

Those very minute living creatures, which cannot be seen without the aid of the microscope, are found principally in fluids of various kinds, especially those in which any animal or vegetable substance has been infused; for which reason they are called animalia infusoria. Some of these, as the genus vorticella, which is a beautiful transparent animalcule, exhibit the appearance of branches of animated flowers. To this tribe, also, belongs that wonderful animalcule, called the wheel-animal; which has a curious apparatus of arms on each side of its head, resembling wheels, by the rotatory movement of which a current is made in the drop of water it inhabits, and the animalcules designed to be its food are brought within its reach. To these may be added the volvox globator, which spins round, as if on an axis; and is always pregnant with many smaller animals of its own kind; and the monas termo, which, when examined by the most powerful magnifying glasses, appears but as a moving point.

QUESTIONS.

By what characters are insects distinguished from other animals? What is the mode of production of most insects; through what states do they successively pass? What is there remarkable in the eyes of insects? In what respects do the muscles of insects differ from those of other animals? What is the Linnæan classification of insects? What insects belong to the different orders? How are the mollusca divided by Linnæus? What is their general food, and how are they produced? What extraordinary animals belong to the several orders of mollusca? What are corals and madrepores? What are the most remarkable of the animalia infusoria?

CHAP. XXXII.

ZOOLOGY—continued.

CLASSIFICATION OF CUVIER.

Cuvier divides the whole animal kingdom into two great families; namely, animals who have vertebræ and red blood; and animals who have no vertebræ, and whose blood is almost universally white.

These are subdivided into various orders.

Vertebral animals have universally an internal articulated skeleton, supported by a strong pillar formed of several bones placed one above another, called the spine of the back, or the vertebral column. This column joins the head, and incloses, in a conduit, running through its whole length, the spinal marrow, or common fasciculus of the nerves. In many animals, the other extremity of this column, the spine, or back bone, is prolonged to form a tail. The ribs which are found in almost all animals of this class, are attached to the sides of the vertebral column. In vertebral animals, the brain is always contained in a particular bony cavity of the head, called the cranium. All the nerves of the spine contribute, by filaments, to the formation of a nervous plexus or network, that derives its origin from some of the nerves of the cranium, and is diffused over most of the viscera.

Vertebral animals have five senses, and the circulation of their blood is kept up by a strong muscle, named the heart. They have, also, organs for secreting dissolving liquids, called liver and pancreas; another called the spleen, that prepares the blood previous to its reaching the liver; and two kidneys; vessels for the secretion of the urine, situated on one side of the spine.

The vertebral animals are divided again into two branches, those having warm blood, and those whose blood is cold. The warm-blooded vertebral animals have a double circulation of the blood, breathe by lungs, and cannot live without respiration. The trunk of their body is always surrounded by ribs, and almost all of them have four members. Their brain exactly fills the cranium. They have palpebræ or eyelids. Their ear has a tympanum or drum. Their nostrils communicate with the back of the mouth, and serve as a passage for the air in respiration.

The cold-blooded vertebral animals are distinguished rather by privations than by common properties. Many of them are destitute of ribs; others have no members. Their brain never occupies the whole of the cavity of the cranium.

Their eyes are very seldom furnished with moveable palpebræ.

Each of these two branches is farther divided into two classes. Warm-blooded vertebral animals are arranged under the heads of mammalia and birds.

The mammalia are viviparous and suckle their young; the birds are oviparous, and bring their young to life and perfection by the heat of their bodies.

Vertebral animals with cold blood, are fishes and reptiles.

Animals without vertebræ, when they have hard parts such as bones or shells, those hard parts are generally external, inclosing the softer parts of the body. Their nervous system has not its connecting parts inclosed in a bony case, but floats in the same cavity with the viscera. Their brain is just over the alimentary canal. They do not respire by cellular lungs; and none of them have any voice. Their jaws are in various directions, and frequently their mouths are only suckers or pumps. When they have articulated, that is jointed, members, such as legs, they are never fewer than six.

Invertebral animals are distributed into four classes.

First, the Mollusca, or soft-bodied animals. These animals of this kind respire by branchiæ. Their brain is a distinct mass, from which proceed the nerves and spinal marrow. Their external organs of sense vary as to number. In some the eyes and ears are very perceptible, while others appear to enjoy only the senses of tasting and feeling.

Second, Crustacea. The animals of this kind have their bodies covered with scaly pieces, and frequently have a considerable number of articulated members. Their nervous system is a long knotted cord. They have hard moveable eyes, composed of different parts. Their ears are very imperfect. Their organs of touch consist of antennæ and feelers. They have a heart with arteries and veins. Their jaws are transverse, strong, and numerous. Their stomach has internal teeth.

Third, the Insect tribe. The animals of this tribe, when in their perfect state, have antennæ and articulated members. The greater number of them have wings. They have a nervous system, but no heart nor blood-vessels, and respire only by trachiæ, orifices. They pass through three states of existence, one of which is completely motionless. To this tribe are joined those animals which resemble the larvæ of insects, and which have also a knotted medullary cord, though they do not undergo the changes that insects experience. Such are earth-worms and leeches.

Fourth, the Zoophytes, These are formed like a star, or the radii of a circle, in the centre of which is placed the mouth. They have neither heart nor blood-vessels, nor any perceptible brain or nerves.

These general divisions are farther subdivided by Cuvier, into several orders.

The Mammalia.

The Cetacea; which have smooth skins, covering a great mass of fat. They have no hind feet; their neck is short, their tail very thick. They have no external ears, and their teeth enable them to catch their prey, but not to masticate. The animals of this kind live constantly in the water. Through the nostrils they expel the superfluous water which they take in at their mouth when they swallow their prey. Their bones and articulations are so much concealed under the skin, that they resemble oars rather than arms or legs, and are fitted only for swimming.

The animals which are classed in the second order of mammalia, have their toes enveloped by horn, and from that circumstance are called cornipeda. These are all herbiverous, and their teeth are fitted, therefore, for bruising vegetables. They form three families; the Ruminantia, those that chew the cud; the Pachydermata, or thick-skinned; the Solipeda, those that have only one apparent toe to each foot.

The animals of the third order of mammalia have distinct toes, covered at the extremities only with nails or claws.

These are also distributed into several families; the Tardigradæ, or slow-walkers; the Edentata, many of whom are entirely destitute of teeth; the Rodentia, or those who, from the nature of their teeth, are obliged to gnaw their food. In some of these animals, as the jerboa and the kangaroo, the fore legs are so much shorter than the hinder, that they cannot be employed in walking. The Sarcophaga, or flesh-eaters.

The mammalia who are amphibious form a small family, whose members are so short, that that they scarcely serve any other purpose than that of swimming.

The bats form another small family of mammalia, with distinct toes. The intervals between their toes, which are very long, and those between their other members, being occupied by a fine skin, exhibit the appearance of wings, and enable these animals to fly.

The Quadrumana form the last order of mammiferous animals; and they most resemble man. Like man, they have the thumb separate from the fingers; their feet are similarly formed; and their teeth resemble those of man; excepting that the canine are longer than the other teeth.

The birds are subdivided into the following families.

Birds of prey, who are carnivorous, and distinguished by strong-hooked beaks and claws. Some of these feed on fish, and others on worms.

Anseres, who have short palmated feet, a close plumage, moistened by an oily liquid, and who live almost entirely in the water.

Grallæ, or wading birds, who have long necks, bills, and legs.

Gallinaceous birds, having short arched bills, and who live upon grain. For the grinding of this hard food, they are furnished with a strong fleshy muscle, called gizzard, capable of breaking very hard substances.

Scansores, or climbers, distinguished by having two toes placed before and two behind.

Passeres; including all the other genera of birds.

Reptiles are arranged in three divisions: Those which have no feet, but who have very long bodies with corresponding viscera. Both their jaws are moveable, and can therefore be opened so wide as that the animals can swallow substances thicker than themselves. They have a cartilaginous and forked tongue, inclosed in a sheath, from which they can protude, and into which they can retract, it at pleasure. To this family serpents belong.

Those that have two feet; to which tribe belong very few reptiles.

Those that have four feet; some of which, as the tortoise, are partly covered with an osseous shell. Others, as the lizard race, have a covering of scales, while frogs, which are of this family, have merely skins. The tortoises and lizards lay eggs with hard shells, from which their young issue forth, under the form which they always retain. The frogs lay soft eggs, that swell after they are deposited in water, and produce young animals, in appearance like fishes, which live in the water, till, in proper time, they assume the form and habits of their parents.

Fishes are distributed into two families:

The Chondropterygii, of which there are very few, and which resemble some reptiles, form one division; while the second comprehends all the other kinds of fish; the only distinction among whom is founded upon the structure of the bones, and divides them into cartilaginous and osseous.

The class Mollusca is divided into three families.

Cephalopeda, or those which have their feet attached to the head. Their body is formed like a sack, and they have three hearts. They respire in water by branchiæ, and their mouth, resembling a beak, is placed in the middle of their feet. They have large eyes, internal ears, and a muscular stomach like a gizzard. They have likewise a particular gland, that secretes a black liquid, by throwing out which they darken the water around them.

The second family consists of animals named Gasteropoda, because they crawl on their bellies.

The Acephala, or animals whose heads are not apparent, form the third family of Mollusca. Their head is folded up in a fleshy hood, so that they seem to have only a mouth. They have double shells. Many of them have no loco-motion, but remain continually attached to rocks. Insects are arranged under two great branches. The first comprehends such as cannot masticate solid substances, and which subsist only by sucking vegetable or animal juices. These are either Hemiptera, which undergo a semi-metamorphosis, and which have a sharp rostrum containing several bristles capable of cutting the skin. Others, called Diptera, experience a complete metamorphosis. The perfect insect has two wings; a sucking tube, armed with bristles or lancets, and some of them have a fleshy proboscis with two lips. Their larvæ resemble worms.

The second great branch, that of insects provided with jaws, and feeding upon solid substances, includes, likewise, several orders.

The Coleoptera; having two wings folded under two cases.

The Orthoptera; the cases of whose wings are soft, and fold up like a fan.

The Neuroptera; having four membraneous articulated wings.

The Piezata, which have four wings, veined, but not articulated, or formed like a net.

The Zoophytes are divided into two orders; the Echinodermata, which have feet, teeth, a distinct stomach, an intestinal canal and respiratory organs. To these belong the sea-urchin and star-fish.

The second order consists of those that have digestive and respiratory organs, but no teeth. To these belong the medusæ, the actiniæ, and others.

The Polypi, or Polypes, which form the last tribe, whether they be naked, or have calcareous coverings, called corals, seem to consist of a gelatinous or jelly-like sack, the opening of which is surrounded by tentacula. Others of the polypi, are of a green, brown, or yellowish colour, having at once the appearance of a plant and the motions of an animal. When cut into pieces, each piece reproduces every deficient organ, and becomes a perfect animal, capable of movement, and of seizing its prey. These are small water animals, of a very tender substance, furnished at the upper part with several long slender arms, by means of which they obtain their food.

This creature produces its young principally by a kind of vegetation. Small swellings, or tubercles, appear at intervals on different parts of the body, which, in the space of a few days, become complete animals, resembling their parents in all respects but size. When thus fully formed, they drop off, and attach themselves to any convenient object. These animals are very voracious, and the act of seizing their prey is sudden and violent, but their mode of swallowing it is very gradual. So rapid is the multiplication of the common polypus, that a single one is computed to produce many thousands in the space of a summer.

They are placed in the lowest rank of animate beings, and seem to form the connecting link between the animal and vegetable kingdoms.

QUESTIONS.

How does Cuvier divide the animal kingdom? What are vertebral animals? Where is situated the brain of vertebral animals? How many senses have vertebral animals? How is the circulation of the blood kept up in them; and how is the dissolving liquid secreted? How are the vertebral animals subdivided? What are the peculiarities of the warm-blooded, and of the cold-blooded vertebral animals? Into what classes are the warm-blooded vertebral animals divided? and what are the chief characteristic differences of those classes? How are the cold-blooded vertebral animals divided? What are the peculiarities of those animals? Into what orders or families are the invertebral animals divided? What are the characteristics of the mollusca? Of the crustacea? Of the insect tribe? Of the zoophytes? Into what orders are the mammalia distributed, and what are their respective peculiarities? Which of the mammalia are most like man? How are the birds subdivided? What are the distinguishing marks of those subdivisions? How are reptiles arranged? What are their respective peculiarities? What are the families of the mollusca? What are their chief differences? How are the zoophytes divided, and what are their characteristics? What peculiarities mark the polypi.

CHAP. XXXIII.

ANATOMY.

THE HUMAN BODY.

Anatomy is the name of that science which treats of the structure and parts of bodies, and points out their various uses.

The most remarkable difference of structure between man and the other animals which inhabit the earth, is his erect figure, that enables him to take a more extensive view of the beauties of creation. In this respect, indeed, the Ourang Outang approaches very near to him, being furnished with muscles, by which he is able to walk upright; but he has one rib on each side more than man has; and the structure of the parts about the larynx is such, as to render it almost impossible for him to utter articulate sounds.

The bones of the human body may be considered as the bases on which the other parts depend for support and figure. They are covered with a rough membrane, called the periosteum, the chief use of which is to hold blood-vessels for their nourishment.

The bones are moveably united to one another, either by a ball and socket, which give them movement in every direction, as in the shoulder; or by a hinge that allows of motion in two directions only, as in the knee; or by a long process, or projection of one bone received into the cavity of another, which admits of a rotatory or circular movement, as in the articulation or jointing of the first and second vertebræ of the neck.

The bones are immoveably united to one another, either by numerous processes of two bones, like the teeth of saws, as in bones of the head, or by the intervention of cartilage.

All the bones of the body, connected in their respective natural situations, form the skeleton.

The bones of the head are the cranium; the case which surrounds and protects the brain; the bones of the face, consisting of two jaws, the upper of which has six bones on each side, and one in the middle, while the lower has only one, in the shape of a horse-shoe, capable of extensive and powerful motion; the teeth, of which there are sixteen in each jaw; so that, including a small bone under the chin, called Os Hyoides, the head is made up of sixty-three pieces of bone.

The teeth are bones fixed in sockets of the upper and lower jaw. Their roots are perforated at their extremities, in order to receive nerves and blood-vessels. They are divided into three orders. Four in the front are called incisores, or cutters. Next to these, on each side, is placed a tooth, which, from its pointed form, is named canine; on each of these again stand five teeth, called molares, or grinders. The last tooth on each side is named dens sapientiæ, the wise tooth, from the circumstance of its not protruding till the body is full grown.

The bones of the trunk are the spine or backbone, the thorax or chest, and the pelvis.

The spine consists of twenty-four pieces of bone, called vertebræ, of which seven belong to the neck, twelve to the back, and five to the loins. Its separate bones are joined to one another by cartilages, in the centre of each of which is contained a fluid, having all the resistance of a solid body, without its hardness.

The head is connected with the upper vertebra by two projections of that vertebra, being received into corresponding cavities in the under part of the cranium. By means of this joint the head is easily moved backwards or forwards on the spine, and there is a curious provision made for a rotatory motion of the head, absolutely necessary for comfort and convenience. The spine serves to support the body in an erect posture, and, at the same time, by the number of joints of which it is composed, admits of a free motion, without danger of pressing upon the spinal marrow, which is extended through the middle of it, and which it is designed to protect.

The thorax is a bony cavity, narrow above, wide below, and arched behind. It consists of the sternum or breast-bone, and twenty-four ribs, which are of nearly a semicircular form. Their uses are to form the sides of the thorax, to enable it to extend or contract itself in breathing, to defend the viscera of the thorax, to receive a variety of muscles, and to support the breast.

The pelvis constitutes the lowest part of the trunk. Its office is to form an arch between the trunk of the body and its lower extremities, and to contain and guard many important organs.

The bones of the lower extremities are, the os femoris, or thigh bone, which is the longest in the whole body, the leg bones, the tibia, the tibula, and the patula, or knee-bone, whose uses are to protect the joint, and to answer the purpose of a pulley to the muscles which extend the leg; the bones of the foot, which are the tarsus, which consists of seven pieces of bone, and which is connected with the bones of the leg; the metatarsus, consisting of five cylindrical bony pieces; and the toes, which are connected with the metatarsus. The great toe has only two joints, the rest have three.

The bones of the superior extremity of the body are the humerus, or shoulder; the brachium, or arm; the anti-brachium, or fore arm; and the manus, or hand.

The shoulder is composed of two bones, the scapula, or shoulder-blade, and the clavicula or collar-bone. The scapula serves for the articulation of the arm-bone, for the insertion of a number of muscles, to add force and extensiveness to the motions of the arm, and for a defence to the hinder part of the trunk.

The clavicle supports the shoulder, and other parts of the superior extremity, protects certain large blood-vessels in their passage to the arm, and connects the scapula to the thorax. The os humeri is a cylindrical bone, which has a round head, that is received into a cavity of the scapula. The anti-brachium, or fore-arm, consists of two bones, the ulna and the radius. By means of the curious contrivance of these two bones, the gracious Author of our frame has rendered the fore-arm capable of a number of most useful movements, while the legs have a more firm and secure structure, with only a hinge joint for necessary movements.

The bones of the hand are, the carpus, the metacarpus, and the fingers. The carpus, or wrist, is composed of eight small bones, of irregular shape, and ranged in two ranks. Their principal use is to render the hand more flexible. The metarcarpus bones, and those of the fingers, are similar to those of the metatarsus, and the toes.

QUESTIONS.

What is anatomy? What is the most remarkable difference between the structure of man and that of other animals? What are the bones and their use? What is the skeleton? What is the grand division of the bones? What are the bones of the head? The bones of the trunk? The bones of the lower extremity of the body? The bones of the upper extremity of the body? What is the periosteum and its uses?

CHAP. XXXIV.

ANATOMY — continued.

MUSCLES AND INTEGUMENTS.

THE animal substance which is called muscle, is what we commonly name flesh. The muscles are the immediate instruments of all the motions of the animal machine, considered in relation to which, the bones are merely levers. Most muscles have others opposed to them, which act in a contrary direction, and are called antagonists. Thus one muscle, or one set of muscles, bends a limb, another extends it; one elevates a part of the body, another depresses it; one draws it to the right, and another to the left.

The principal muscles belonging to the head are are follows:—A single broad muscle, and a pair of small muscles, serve to move the skin of the head, the forehead, and the eye-brows. A muscle which surrounds the eye, has the power of closing the eye-lids; and another proper to the upper eye-lid, serves to raise it. Six muscles perform the various movements of the eye-ball. One pair is peculiar to the nose, to contract the nostrils, and to wrinkle the skin. The mouth has nine pair of muscles to carry on its different operations. Four pair of muscles move the lower jaw. Two muscles in the neck, turn the head to one side or the other, or bend it forwards.

Six pair of muscles are situated between the small bone under the chin, and the lower jaw. Two muscles pass from the os hyoides, to the trunk, bending it downwards.

The substance of the tongue is muscular, and distinguished into six pair of muscles. There are also several muscles belonging to the internal parts of the mouth and throat.

The principal muscles of the trunk are, four on the fore part of the neck, which serve to bend the head and neck side-ways, or to depress them; a multitude on the back of the trunk, whose office it is to perform motions of the shoulder-blade, the arms, the ribs, the backward inclinations of the head and neck, to strengthen the spine and prevent it from bending forwards, to assist in erecting the trunk, to extend the neck and spine backwards or obliquely.

On the fore part of the thorax are numerous muscles also, to perform various movements of the scapula, the clavicle, the ribs, and thorax.

But the most important muscles of the trunk are the diaphragm and the heart, internal muscles.

The heart is a hollow muscle included in a membranous bag, called the pericardium, which contains also the great vessels arising from it.

Within the pericardium is likewise a quantity of transparent fluid, which, by preventing frictions, facilitates the motions of the heart. In man, the heart is placed transversely; its upper surface is convex, while the lower surface is flat. The principal part of the muscular substance of the heart forms two cavities, called the right and left ventricle. At its basis are two other cavities, called the right and left auricle. Each of these communicates with the nearest ventricle, by a valve opening inwards towards that ventricle. Similar valves are placed also at the mouths of the large arteries, to prevent the blood from passing in any other than the proper direction.

Each auricle communicates with a large vein, and each ventricle with a large artery. The use of the auricle is to receive the blood from the vein, and to discharge it into the cavity of the ventricle, whence it is driven forcibly into the artery. By the repetition of these operations, is performed the circulation of the blood.

The diaphragm is a strong, broad, muscle, which divides the thorax from the lower part of the trunk, called the abdomen. Upon this muscle the heart rests. .The abdominal muscles effect several movements of the lower trunk and thighs.

The chief muscles of the lower extremities are eleven, situated on each thigh, which move the legs in various directions, as ease or utility demand; twelve muscles, which being placed on each leg, produce the necessary movements of the feet and toes; four small muscles under each foot, rendering more extensive the binding of the toes, and draw them inwards.

The principal muscles of the superior extremities, are seven, situated on the scapula, and inserted into the os humeri, which serve to raise or depress, and to turn inwards or outwards, the shoulder and arm; while four, placed on the os humeri, move the fore arm in its various directions; and numerous muscles on the fore arm that extend or contract the hand and fingers, roll the radius on the ulna, and expand the thumb.

The cellular substance is a loose fibrous web, consisting of cells that communicate with one another. This substance forms a large part of the human body, for it is interposed between all the muscles, and bundles of muscular fibres. It connects the muscles, and preserves them in their relative situations, and yet it is sufficiently yielding to give free play to all their motions, while its smoothness prevents friction.

The integuments, or wrappers of the body, are the skin, properly so called, and the scarf skin, or epidermis.

The skin appears to be a condensed cellular substance, furnished with blood-vessels, lymphatics, and nerves. It grows gradually thinner internally, until it is insensibly absorbed in the loose cellular substance. This integument covers the whole surface of the body, is tough and elastic, forming the organ of touch by means of the nerves that terminate in it; especially at the extremity of the fingers, where it has most sensibility. The epidermis, or scarf skin, completely covers the true skin, or cuticle, which would otherwise occasion great uneasiness by its extreme sensibility. The epidermis consists of a mucous substance placed next the true skin, and of a dry transparent substance placed without. The mucous substance is differently coloured in different subjects, white, brown or black, and occasions the different complexions of different people. The epidermis not being provided with nerves, is insensible.

The hair and nails are esteemed by some anatomists, to be productions of the epidermis. The hairs rise from separate, oval bulbs, placed beneath the true skin, and lodged in the cellular substance. Each hair is inclosed in a sheath, which rises with it as far as the surface of the body. The nails are horny, insensible substances, formed of thin lamella, or plates. They rise by a square orgin, from the last joints of the fingers and toes. The parts of them exposed to the air, are hard, but those which are under the skin, are soft.

QUESTIONS.

What is a muscle? Of what use are muscles? What are the chief muscles of the head? What are the muscles of the trunk? What is the heart? What are the muscles of the lower extremities of the body? Of the upper extremities? What are the integuments of the body? The skin? The hairs? The nails.

CHAP. XXXV.

ANATOMY — continued.

INTERNAL ORGANS OF THE BODY.

THE abdomen, or lower region of the trunk, is bounded, above by the diaphragm; below, by the bones of the pelvis; at the sides, by various muscles; before, by its own muscles; behind, by the vertebræ, the loins, and by the bone called the os-sacrum. A thin membrane, called the peritoneum, forms an internal covering to these parts, and includes the mesentery, the omentum, the stomach, the small and great intestines, the lacteals, the pancreas, the spleen, and the liver.

The mesentery includes all the blood-vessels and nerves which belong to the intestines, the numerous vessels, called lacteals, that take up the chyle, or preparation from the swallowed food; and the glands for secreting necessary liquids and juices.

The omentum is a fold of the peritoneum, containing cellular substance, and a large quantity of fat.

The stomach is a membraneous sack or pocket, much larger towards the left side than the right. The stomach is the receptacle for food, in which it undergoes the process of digestion. It has one opening for receiving food, and another for the passage of it after it has been partly prepared for the purposes of nourishment. It is abundantly furnished with nerves, blood vessels, and lacteals.

The name intestines, is given to the whole of the alimentary tube, (the tube for the passing of the food,) which is below the stomach. The intestines are divided into large and small. The latter occupy the middle and fore parts of the abdomen, while the former occupy its upper, under, and side parts. The small intestines assist in the preparation of the chyle, and propel their contents towards the great intestines.

The liver is an organ of a deep red colour, immediately beneath the diaphragm. The human liver is divided into two lobes, and its use is, to prepare the bile, a liquid necessary to the process of digestion.

The spleen is a spungy substance of a colour between deep red and blue. Its use is not well known, it is, most probably, intended as a counterpoise to the liver, as may be inferred from its size.

The pancreas is a glandular organ, of a pale red colour, and, in some animals, is called the sweetbread. It is situated behind the stomach, and in form resembles a dog's tongue, secreting a fluid very like the saliva of the glands of the mouth.

The kidneys are two organs of a pale red colour, and firm consistence, in form, like those beans that bear the same name. They are connected with the bladder by two tubes, called ureters, which convey to the latter, the liquid secreted in the former, and which are so sensible, that any hard substance passing through them, occasions acute pain.

The vesica, or bladder, is a membraneous sack of considerable size, generally of a round, oblong, form, situated in the fore part of the pelvis. Its uses are, to receive the liquid secreted in the kidneys, to retain it for some time, and then, finally to expel it.

The upper region of the trunk is called the thorax. It is surrounded by the spine, the ribs, the sternum, the diaphragm, and is covered internally by a thin membrane, called the pleura. It contains that most important muscle, the heart, with its large vessels, and the lungs.

Arteries are tubes which convey the blood from the heart.

Veins are tubes which convey the blood to the heart. The arteries have a pulsation, or beating motion in them; the veins have none.

The lungs, an organ of fine net-work, composed of very minute ramifications of air-vessels and blood-vessels, which fills two bags formed by the pleura. The colour of the lungs is, in infants, reddish; in adults, greyish; in old persons, dark blue, or black. The lungs are connected with the neck by means of the wind-pipe, and with the heart, by blood-vessels. By them is performed the important operation of breathing.

The wind-pipe is a tube formed of annular cartilages, membranes, and muscular fibres. After it enters the cavity of the thorax, it is divided into two great branches, which are subdivided again, and under the name of bronchia, are distributed through the substance of the lungs. Through this organ, the atmospheric air is conveyed to the lungs.

The larynx is a tube situated behind and below the tongue, at the anterior part of the neck. The larynx is connected with the wind-pipe, at its basis. Over the larynx is placed a cartilaginous substance, called the epiglottis. In the act of swàllowing, when the tongue is drawn backwards, the epiglottis exactly closes the opening of the larynx, so as to prevent the food from entering it. This is the organ by which the human being produces sounds.

The pharynx is a muscular bag, shaped like a funnel, beginning from the basis of the cranium, and terminating in the œsophagus, or gullet. By muscular fibres, it is connected with the larynx, which is suspended in its cavity. The use of the pharynx appears to be, to receive the food, and to impel it into the œsophagus.

The œsophagus, or gullet, is a membraneous tube, beginning from the narrow termination of the pharynx. It is situated between the vertebræ of the neck, and the wind-pipe, and, descending below it, is embraced by the pleura in a triangular space. Having arrived at the bottom of the thorax, it passes on the left side, through the diaphragm, and terminates in the cardia, or left orifice of the stomach. This organ conveys the food to the stomach.

QUESTIONS.

What is the abdomen? What is the omentum? What is the stomach? What are the intestines? What is the liver? What is the pancreas? What are the kidneys? What is the vesica, or bladder? What does the thorax contain? What lines the thorax? What are arteries and

veins? What is the organ called the lungs? What is the wind-pipe? The larynx? The pharynx? What is the œsophagus?

CHAP. XXXVI.

ANATOMY — continued.

THE PROCESS OF DIGESTION — CIRCULATION OF THE BLOOD — RESPIRATION.

When the food has been masticated, or cut and bruised by the teeth, and softened by the saliva, it is conveyed to the gullet by muscles designed for that purpose. In its passage it presses down the epiglottis, so as to prevent any portion of it from entering the wind-pipe, and is thus regularly, but rapidly transmitted to the stomach. There the food is farther softened by the action of a dissolving liquid, called the gastric juice, secreted by glands in the coats of the stomach, and reduced to a pulpy consistence, called chyme. It then passes through the pylorus, or right orifice of the stomach, into a part of the small intestines, called the duodénum, where it remains for some time, and is rendered still thinner by the mixture of bile from the liver, and a liquid which comes from the pancreas. It is pushed backwards and forwards in the small intestines, by a muscular contraction of their coats, called the peristaltic motion. As it proceeds, its fluid parts are continually taken up by the lacteals, and consequently, it becomes of a thicker consistence, and is called chyle. From the small it passes into the larger intestines, where more of its fluid particles are absorbed by the lacteals. Finally, it is received by the end of the intestinal tube, called the rectum, and all its nourishing parts being taken up, the useless remainder is expelled from the body. The chyle, which is the product of the food thus digested, enters the lymphatics, is conveyed to the heart, and mingles with the general mass of the blood.

The circulation of the blood is performed by an admirable and curious operation. From the anterior auricle of the heart, the blood passes into the anterior ventricle. Thence it is transmitted into the lungs by an artery, called the pulmonary artery. Meeting the atmospheric air in the lungs, it imbibes oxygen, or vital air from it, and is thereby rendered red and pure. From the lungs, the pulmonary veins bring it back to the heart, where it enters the posterior auricle, from which it passes into the posterior ventricle, and thence is carried to every part of the body by the aorta, a very large artery branching out into smaller arteries. It then returns to the anterior auricle of the heart by the venæ cavæ, after having been impelled through innumerable mazes of arteries and veins.

Thus the blood is constantly carried through two circles, a small one between the heart and the lungs, and one much larger between the the heart and the rest of the body. The heart is the principal, but not the only organ of this astonishing process, for every vessel through which the blood passes, by its contractile power, assists to propel the current. The heart, by contracting suddenly and strongly, begins the movement. These contractions throw the blood into the arteries, and occasion their pulsation. The blood losing the greater portion of its oxygen, during this progress through the body, loses also its red colour and purity, and returns to the heart almost black. By its contact with the air in the lungs it is revivified.

Respiration is likewise a very curious process. The air rushing through the wind-pipe, is conveyed by its ramifications, to the air-vessels of the lungs. After inspiration, or drawing in air, the air-vessels, which are like small bladders, are fully distended. The small and numerous ramifications of the pulmonary artery, are distributed on the membranes of these air-vessels, and through their membranes, without coming into actual contact with the blood, the air produces those changes in it, which are necessary to the continuance of life.

The atmospheric air, after having imparted its oxygen to the blood, is ejected by the contraction of the muscles of the thorax. The chief uses of respiration appear to be, to effect certain changes in the blood, and to produce animal heat.

QUESTIONS.

How is the process of digestion carried on? How is the circulation of the blood performed? What is respiration? What are the uses of those curious operations?

CHAP. XXXVII.

ANATOMY — continued.

HUMAN ORGANS.

The mouth contains, besides the teeth, the palate, or arched roof, the uvula, that small pointed body at the back of the mouth, where the arches of the palate unite; the tonsils, oblong bodies which open into the throat by several ducts; the salivary glands, which secrete the saliva.

The tongue, which is the organ of taste, and of articulation. On the surface of this organ are discernible a kind of pimples, called papillæ. These are furnished with blood-vessels and nerves, and these are the true organs of taste. Under them is the muscular substance of the tongue. The muscles of the tongue are very numerous, and by their aid it is moveable in all directions. By its movements it assists in articulating the sounds formed by the passage of air through the larynx.

The nose, the organ of smell, is composed of two bones, gristle, or cartilage, and the nostrils. A soft porous membrane, furnished with papillæ and numerous vessels, which is spread upon the internal surface of the nostrils, is the immediate organ of smell. Particles inconceivably minute, emitted by odoriferous substances, striking upon this membrane, excite it, and occasion what we call smell.

The Ear.—The external ear, which, from its resemblance to a certain sea-shell, is termed concha, is a cartilaginous funnel of an irregularly oval form, moveably connected to the head by ligaments, muscles, and cellular substance. The funnel, growing narrower internally, terminates in what is called the external auditory canal. The cutis and epidermis, are continued into this, but become much thinner and more sensible, and are furnished with minute hairs, by which the approach of any insect, or injurious substance, is immediately notified. This passage is closed by a membrane, called the drum. Within the tympanum, or drum, are four small bones, and a space called the labyrinth, in which are situated the vestibulum, or porch, which is a cavity of a circular form; three semi-circular canals, opening into the vestibulum, and a body named the cochlea, as it bears some resemblance to a snail-shell.

Every part of the labyrinth is supplied with a watery liquid, which is supposed to receive the vibrations that constitute sounds, and to propagate them to the nerves. Sounds entering the concha of the ear, which is skilfully formed to receive them, are transmitted to the auditory tube, where they strike upon the elastic membrane, the tympanum; by the small bones behind which, they are communicated to the parts of the labyrinth, and operate upon the delicate nervous film by which those parts are lined.

This structure of the ear is admirably calculated to augment and echo sounds with force and exactness.

Sound is not, however, conveyed to the internal ear, by the concha exclusively. There is a passage communicating with the mouth, called the Eustachian tube, by which air finds admittance to the cavity of the tympanum, and thus its undulations may be transmitted to the labyrinth.

The Eye.—The eyes are situated in two cavities, called orbits, the bones of which defend them from external injuries. These orbits are lined with fat, on which the eyes rest as on a soft cushion, and perform their different movements with ease and safety. The globe of the eye is immediately covered by the eye-lids, the edges of which are formed by rims of cartilage, called tarsi, and on their margins are glands emitting an oily fluid to prevent their adhesion; and hairy fringes, called eye-lashes, to secure the eyes from dust. The surface of the eyes is always moistened by a very fine limpid fluid called tears, which, after having washed the eye, arrives at its internal angle, when it is conducted by passages to the nose. The ball of the eye consists of three coats.

The outward one of which, a white and glistening substance, is named the sclerotica; the next, abounding in blood-vessels, is called the choroides; the internal coat of all is named the retina, and is a very tender net-work, formed by the expansion of the optic nerve.

These coats are only at the sides and back of the eye, for at its fore part, is a transparent circular body continued from the sclerotica, and called the cornea, with a web-like membrane of different colours in different persons, named the iris. In the middle of the iris is an opening, which is dilated or contracted by the power of the iris. This opening is called the pupil, and through it the rays of light pass to the internal part of the eye.

Three substances, called the vitreous, the crystalline, and the aqueous humours, fill the ball of the eye. The optic nerve does not enter the eye immediately behind and opposite to the pupil, but rather towards the nose.

The operation of vision is thus conducted. The rays of light reflected from the object towards which the eye is directed, fall upon the transparent cornea, and are there refracted so as to enter the pupil, and in passing through the crystalline humour, they are again refracted, and are converged to a point, or focus, upon the retina, where they form an inverted picture of the object, whence the optic nerve conveys the impression to the brain.

QUESTIONS.

What does the mouth contain? What is the tongue? What is the construction of the nose? What is the structure of the ear? What is the structure of the eye? How is the operation of vision conducted?

CHAP. XXXVIII.

THE BRAIN.

THE brain is a pulpy substance, made up of various convolutions, which completely fills the cavity of the bony case, called the cranium. It is commonly considered as consisting of two parts; the cerebrum, which occupies the upper and largest portion of the cranium; and the cerebellum, which is seated in its lower and hinder part. Each of these parts of the brain is divided into two portions by peculiar membranes.

The brain is enveloped in two membranes, of which the external, called the dura mater, is thick and insensible, abounding in blood-vessels. Its external surface lines the inner part of the head; the inner membrane is named the pia mater; it is very fine and delicate, not only wrapping the brain, as in a soft caul, but entering in between its convolutions.

A medullary mass, common to the cerebrum and cerebellum, situated in the lower and back part of the cranium, is called the medulla oblongata.

The medulla spinalis, or spinal marrow, is a continuation of the medulla oblongata, which passes through the great opening of the cranium, and is conveyed down the long canal formed by the vertebræ. The medulla spinalis gives rise to about thirty pair of nerves. As they descend, they run more and more obliquely downwards, till, at the second vertebræ of the loins, the spinal marrow is split into innumerable fibres like threads, and from the appearance it then presents, is called the horse's tail.

The brain appears to be the seat of percipience, of intelligence, and sensation; the organ of thought. It is the root of all the nerves, and to it the organs of the different senses communicate the impressions made upon them, and convey notices of external objects.

If the communication between the brain and any parts of the body be cut off by disease or any other means, those parts become insensible and paralysed. Near the sources of the optic nerves in the brain there is a small body of an oval shape, called the pineal gland, which the illustrious French philosopher, Descartes, supposed to be the seat of the soul.

The larynx is the organ of the voice, the immediate cause of which is the expulsion of air from the lungs through that organ. The differences and varieties of voice depend on different positions and movements of the larynx. When we endeavour to produce a shrill tone, the larynx is contracted and elevated, when we try to emit a grave and deep tone, it is enlarged and depressed. The motions and structure of this organ seem to prove that it possesses the advantages of both wind and stringed instruments. The voice being produced in the larynx is afterwards formed into articulation by numerous diversified movements of the tongue and lips.

Singing is performed almost entirely by the larynx, though the nose and mouth have some influence in improving and softening the tones, and expressing words. In whispering, the larynx is very little employed; and during this operation seems to transmit the air as a simple tube, like the wind-pipe.

From the beginning and first point of existence, the growth of the human body proceeds in increasing proportion, until birth; after which that proportion diminishes. The growth of the second year is proportionably less than that of the first; and that of each succeeding year is less than that of its immediate predecessor. When the body has attained its full size, it does not immediately begin to decline, but remains in a state of nearly equal vigour, till between forty and fifty. After which period it generally begins to lose its agility, and symptoms of old age gradually manifest themselves; yet, where the constitution is naturally good, and the rules of temperance have been followed, the strength remains tolerably entire. From the age of sixty to that of seventy, the state of health is frequently very pleasant, though the strength fails considerably. When life is protracted beyond the age of seventy, it is most commonly attended by weakness and numerous infirmities. During the whole progress of life, the body is continually becoming less vascular. The fine bloom of youth, which is occasioned by ramifications of minute arteries in the skin of the cheeks, changes to the moderate hue of middle age, and finally to the wrinkled appearance of old age. Similar effects take place in the other parts of the body. That which in the child was pliant cartilage, in the old man becomes brittle bone.

The quantity of earthy matter in the frame is constantly increasing; the muscles become insensible to the usual stimuli, the vigour of the circulation is diminished, and in those few human beings who escape the attacks of the diseases to which they are continually exposed, this rigidity or stiffness continually augmenting, necessarily puts an end to mortal life.

The heart then ceases to beat, the blood to flow, the lungs to respire, the principle of vitality departs, putrid fermentation takes place, the body is decomposed, and returns to the earth.

QUESTIONS.

What is the brain? The cerebrum? The cerebellum? The dura mater? The pia mater? The medulla oblongata? The medulla spinalis? How many pairs of nerves issue from the medulla spinalis? What appear to be the offices of the brain? What is the organ of the voice? How are speaking and singing effected? What is the progress of the human body, from its commencement to its dissolution?

CHAP. XXXIX.

MEDICINE — SURGERY.

Upon the knowledge of the internal and external parts and organs of the human body, and of their various functions, depend the arts of medicine and surgery.

Medicine is the art of preventing, curing, or alleviating those diseases to which mankind are subject.

The first physicians of whom mention is made in history were those who embalmed the patriarch Jacob, by order of Joseph his son. They are styled the servants of Joseph, whence it appears that they were not priests; for the Egyptian priests had too much honour and influence with both king and people to be the servants of any man, however exalted in rank and office.

The Egyptians attributed the invention of this art to Thoth, or Hermes, who engraved its principles in hieroglyphics, upon pillars. These hieroglyphical writings were supposed to have been transcribed into books by Agathodemon, or the second Mercury, which books the priests asserted to have been preserved in the sacred recesses of their temples.

But the system of medicine among the Egyptians appears to have been nothing better than a collection of absurd superstitions. The ancient Greeks, likewise, according to the picture which Homer gives of them in the Iliad, seem to have possessed but a very low degree of this art. Esculapius was the first person among them who had any valuable knowledge of this kind; and his, probably scanty knowledge, procured him such respect, that, after his decease, he was deified by his countrymen. Hippocrates, who claimed the honour of being the seventeenth in descent from Esculapius, was the first who treated of medicine in a regular and rational manner. Hippocrates is supposed to have lived about 400 years before the Christian era. He is the most ancient author whose writings on the medical art are preserved, and he is, therefore, styled the father of medicine. He endeavoured to explain the causes of the diseases of the human frame, and their symptoms; to classify them, and to point out their preventives or remedies. He laid down maxims for the preservation of health; for the regulation of exercise and bathing. He appears to have used purgatives, emetics, venesection, or blood-letting, sudorifics to promote perspiration, moist and dry fomentations, gargles or washes for the inside of the throat, oils and ointments, cataplasms, mixtures or pastes composed of various substances to soften tumours and disperse swellings, and various other compounded medicines. Celsus was another celebrated ancient writer on the subject of medicine. He lived in the time of the Roman emperor Tiberius. In the reign of Adrian, A. D. 131, lived Galen, a native of Pergamus, one of the most illustrious men in the annals of medical science. After the downfall of the Roman empire, the Arabian or Saracenic physicians became illustrious for the knowledge and practice of the art of medicine. To them Europe is indebted for the preservation of the medical science of Greece and Rome, and likewise for the description of many new diseases, and the mode of treating them. Of these, Avicenna was the most famous. Their system of medicine was introduced into Europe very early, with great applause.

In the beginning of the 16th century, Paracelsus, a famous chemist, advanced a new system of medicine, founded on chemistry. In 1628, the celebrated Harvey demonstrated, and communicated to the public the important discovery of the circulation of the blood. This overthrew almost all the former systems, and prepared the way for that highly improved state, in which the medical art exists at present.

When the body has so far declined from a sound state, that the functions of any of its parts are entirely impeded, or performed with difficulty, a disease is said to have taken place.

Every difference in the state of a sick person from that of a person in health, is called a symptom, being an indication of some kind of disease.

The causes of diseases are said by physicians to be either predisponent or exciting. Predisponent causes are such circumstances as produce a tendency towards a disease, and place the body in a state fit for its reception. Exciting causes are those which actually produce disease in a body predisposed to receive such disease.

From the combined action of the predisponent and the exciting cause, arises the proximate cause.

The various diseases of the human body are now almost all well known, and regularly classed, their different symptoms are described, their preventives are pointed out.

Pharmacy is the art of preparing, preserving, and compounding medicines, and the person who practises and makes up the prescriptions of the physician is called an apothecary, and that operation is called dispensing.

Surgery, or chirurgery, a term compounded of two Greek words, signifying the hand, and work, is that part of medicine which treats of the diseases of the human body that may be cured or alleviated by the hand, by instruments, by external applications.

Medicine and surgery were formerly regarded as one and the same science, and were practised by the same persons, though they are now separated.

The healing of wounds by strictures, plasters, and other means, the setting of fractured bones, the amputation of limbs when necessary, and a vast variety of operations by the hand, upon the external and internal frame, are the objects of surgery. This art, by means of the accurate knowledge of anatomy which has been obtained, and the admirable instruments which have been invented, and which are made with exquisite skill, is now brought almost to perfection, and by it the most wonderful and beneficial operations are performed.

QUESTIONS.

What is the art of medicine? Who were the first physicians of whom we read in history? What was the art of medicine among the Egyptians, and to whom did they attribute the invention? What was the state of medicine among the ancient Greeks? Who was the first illustrious physician? What famous physicians lived after Hippocrates? What is disease? What is a symptom? What are the different causes of disease, according to physicians? What is pharmacy? What are the objects of surgery? Whence is the term surgery derived?

CHAP. XL.

PNEUMATOLOGY.

PNEUMATOLOGY is the science which contemplates the operations of the mind or intellectual faculty.

The term is compounded of two Greek words, signifying spirit and discourse or reasoning. The powers or capabilities of the mind may be ranged in the following order, sensation, perception, understanding or reflection, reasoning, judgment, volition, consciousness, memory, imagination.

Sensation may be considered to be the connecting link between the intellectual principle and external objects; the consequence of certain relations established, by our infinitely wise Creator, which human reason has not been hitherto able to comprehend. Relations between the matter of light and the eye produce what we call vision, relations between certain vibrations of the air and the auditory nerves, constitute hearing. We do not know the absolute means by which these effects are produced, but it appears probable that the principal operating cause is impulse. Thus, it is ascertained that the particles of light move in straight lines with amazing rapidity, sound is occasioned by a tremulous undulatory motion of the air capable of being communicated to other bodies.

Odorous particles require the assistance and movement of air to excite the organs of smelling. The objects of taste are more accurately perceived by being pressed closely between the tongue and the palate, and in order to feel any substance, it should be applied to the skin with a certain degree of force. The nerves are the instruments which convey to the brain the impressions made by external objects upon the bodily organs. The mind seems to be the ultimate repository of these impressions, which are called its sensations; for when an organ of impression is lost, the sensations which had been conveyed by it, are not lost with it. Persons who have lost a limb by amputation or other means, have been known to complain of suffering pain in the extremity of the separated member; and of its being affected by changes of temperature.

It is certain that all the impressions which are made in the various parts of the body however distant from the head, are conveyed to the brain by the nerves. But whether the brain itself, by the almighty power of the universal Creator, be made capable of perceiving the vibrations which are excited in its own substance; or whether there be some superior and totally different substance united to it, which, as it were, looks upon what is passing therein as on a picture, is a question, the determination of which is probably beyond the present faculties of man.

Sensation is, then, the first of the intellectual functions, and impressions are its subjects.

The result of sensation, is perception; the mind perceives the sensations conveyed to it through the medium of the bodily organs, the nerves, and the brain. This is the first means by which ideas are raised in the mind. Thus by the operation of the senses, are excited the ideas of light and colours, of sounds, tastes and odours, of heat and cold, and solidity and configuration.

Some ideas are obtained by the medium of one sense only, or by simple reflection, such as ideas of colour, sound taste, solidity, and the simple operations of the mind. Other ideas are the result of two senses, or of the senses and reflection, as of figure, rest, motion, &c. furnished by the senses of sight and touch, or of pain, pleasure, power, &c.; which are very variously produced.

Ideas are distinguished into simple and complex ideas.

Simple ideas are such as are complete in themselves, as the ideas of qualities; solidity, colour, form, &c.

Complex ideas are those formed by the putting together of several simple ideas; as the idea of gold, which is compounded of the several ideas of solidity, weight, malleability, ductility, fusibility, brilliancy and yellow colour.

Ideas which come into the mind by one sense only, may be termed simple ideas; such are the ideas of light, colours, tastes, sounds, odours. They are conveyed by one particular organ of sense; and if that be wanting, they are not communicated by either one of the other senses.

Ideas which come into the mind by the medium of more than one of the senses, or by reflection, or by the combination of sensation and reflection, may be called complex ideas. Such are, the ideas of space or extension, figure, rest, motion, which are raised by impressions of the organs of touch and sight; the ideas of pleasure and pain; of existence, power, and unity, which are the result of sensation and reflection.

Memory is that faculty of the mind which retains, and exhibits again, as occasion requires, all sorts of ideas gained by perception. It consists of two capabilities or acts; the one, is the actual retention of the ideas raised in the mind, which is properly called, memory; and the other a reviewing or calling forth those ideas, which is styled remembrance.

This faculty may be greatly strengthened by due exercise and culture.

Various methods of assisting this power of retaining and recalling ideas have been invented. Such an invention is called artificial memory.

The most ancient of these methods is the following, which is said to have proceeded from Simonides the poet. Form in the mind, the idea of some large place or edifice divided into a number of distinct parts disposed in a certain order; revolve these parts in your thoughts, till you are able to run them over one after another, without hesitation, beginning at any part.

After this facility is acquired, impress upon the mind as many images of living creatures or any other sensible objects which are most likely to impress the memory, and to be soonest revived therein. These objects, like characters or hieroglyphics, must denote an equal number of words which cannot so easily be remembered.

When you wish to commit to memory a number of things in a particular order, place these images regularly in particular compartments of the edifice you have imagined. Then, by going over the several divisions of the building, the images supposed to be placed in them will be revived in the mind, and will bring with them the things or words required to be recollected. If the figure of a lion be made to signify strength, and the word strength be one of those you wish to remember, and it is placed over the entrance of the imaginary building; then, when in going over the several parts of the building, you come to the entrance, the image of the lion will present itself, and suggest the word or idea connected with it. This method was revived and improved upon by Feinagle.

Another method of assisting the memory is by forming certain words, the letters of which are supposed to signify dates, eras, and other remarkable circumstances. The five vowels represent, in their natural order, the first five numerical characters; and from these certain dipthongs are formed. Thus, the vowel a, being taken as signifying the figure, 1, and u, as 5, the dipthong, au, will stand for 6; and as o, signifies 4. and u, 5, the dipthong ou, will signify 9.

Some of the consonants are used in the same way. This is principally of service in remembering dates, though it is applied, also, to other purposes.

Though methods of artificial memory may aid in retaining a number of separate and unconnected words, yet they cannot be applied to any extensive or general purposes; and the most effectual way to gain a good memory is its constant and moderate exercise.

Reflection is that power of the mind by which it observes its own operations concerning the ideas raised in it, and thence collects other ideas, which are equally capable of being subjects of its contemplation, as any of those which it has received from external objects. This is also called understanding. Propositions and evidences are the subjects of this faculty. Its results are complex ideas, emotions, passions, which are compared by the faculty of reasoning, and decided upon by that capacity called judgment; which terminates in volition; which prompts the mind to exert its wondrous power over the animal machine, and employ the curious springs and organs of the body, as its means and instruments. Consciousness of personal identity, of being the same individual creature, accompanies the whole of this mental process, which memory can recal when passed, and from which imagination can form new combinations.

Upon these intellectual powers depend logic, literature, morals, political economy, religion.

QUESTIONS.

What is pneumatology? How may the faculties of the mind be conveniently arranged? What is sensation? What is perception? What are simple and complex ideas? What is reflection? What is reasoning? What is judgment? What is volition? What is consciousness? What is memory? What is artificial memory? What is imagination? What arts depend upon these mental powers?

CHAP. XLI.

LOGIC.

Logic is the art of making a right use of reason, or the intellectual faculties, in the obtainment and diffusion of truth.

The good judgment which any one may exert in the common affairs of life, without the advantages of learning, is termed natural logic; while the higher advancement of the mental powers, by cultivation and exercise, is termed artificial logic.

The rules of logic are framed from those observations which have been made concerning the principal operations of the mind in the process of reasoning. These are, perception, judgment, reasoning, disposition.

Perception, is the simple contemplation of sensations, or objects presented to the mind, without affirming or denying any thing concerning them; as a tree, a flower, leaves, fruit, the properties of height, swiftness, &c. animal motion, &c. Judgment is that operation of the mind by which it connects two or more ideas together by one affirmation or negation; as the tree is high; the fruit is not sweet; God is love; God is good, and doeth good continually; the sinner is not happy. These sentences are the effect of judgment, and are called propositions.

Reasoning is that mental operation, whereby, from two or more propositions premised, an inference is drawn; thus, "a righteous and wise governor will make a difference between the good and the wicked; but God is a wise and righteous governor; therefore God will make a difference between the good and the wicked." Such inferences or conclusions are the effects of reasoning, and the three propositions taken together form what is called a syllogism or argument.

Disposition is that operation of the mind, whereby the ideas, propositions and arguments formed concerning any one subject, are placed in such order as seems most conducive to its being long retained, or best explained to others. It is the ranging of the thoughts in such order as may be best for our own easy conception and lasting retention, and for the ready comprehension and memory of others. The effect of disposition is called method.

The objects of perception, are the archetypes or patterns of ideas.

Every object of an idea is called a theme.

A substance is a being subsisting by itself, without dependence upon any other created being. Thus iron, gold, stone, brass, &c. are said to be substances, because they depend upon God alone for existence.

Properties of substances which we cannot conceive of as existing, without substances to which they belong, or in which they inhere, are called modes; and the substances in which they inhere, are styled their subjects.

We have no absolute knowledge of substances, but by their modes or properties. Thus motion, figure, quantity, are modes of material bodies, and we know nothing of those material bodies, such as metals, stones, wood, &c. but by their hardness, softness, thickness, configuration, malleability, ductility, fusibility, brightness, &c.

Modes are either essential or accidental.

An essential mode is an attribute belonging to the very nature of its subject, and without which that subject could not exist as the being which it is.

Thus roundness is essential to a bowl; heaviness to iron.

An accidental mode is such as is not absolutely necessary to the very existence of a being, since its subject may be deprived of it, and remain of the same nature. Thus smoothness or roughness, colour, are the accidental modes of a bowl, for they may be changed, and the bowl remain a bowl still.

Modes primarily belong to substances, but there are some which are modes of other modes. Though they subsist in and by the substance, as their original subject, yet they are properly and directly attributed to some mode of that substance.

Thus motion is a mode of body; but swiftness or slowness, and direction, are modes of that mode of body, motion walking is a mode of man, but gracefulness of walking is another mode or manner superadded to that action.

Ideas may be considered as being sensible, or intellectual, or abstracted.

Sensible ideas are derived primarily from impressions made upon the organs of sense; and however these being retained by the memory, may by the imagination be increased, diminished, compounded, and diversified, still they derive their first existence from communications made to the mind by the senses. Thus, if imagination devise a mountain of diamond, or an ocean of wine, the ideas of mountain, diamond, ocean, wine, entered the mind at first, through the medium of sensation.

Intellectual ideas are those which are gained by observing, and reflecting upon, the operations of the mind.

By sensation, the mind contemplates external things, and obtains sensible ideas; by reflection, the mind contemplates itself and acquires intellectual ideas.

Abstracted ideas, are ideas, which though flowing originally from sensation, or reflection, or the combined operation of those powers, yet are framed immediately by another act of the mind, called abstraction.

Abstraction is the withdrawing the attention of the mind from those properties of objects which belong to them alone, and directing it to those properties of objects which they possess in common with others, or the withdrawing some parts of an idea from other parts of it, and contemplating them separately. By this means, such abstracted ideas are formed as neither represent any thing corporeal or intellectual; any thing peculiar to mind or body; such are, the ideas of existence, power, act, mode, cause, effect, circle, triangle, square.

The operation of the mind, by which it views two or more objects at once, and thus discerns their mutual relations and connections, is called comparison.

Hence arise the ideas of greater and less, parent and child, brother and sister, ruler and subjects.

QUESTIONS.

What is logic? What is the difference between natural and artificial logic? Whence are the rules of logic derived? What are the principal operations of the mind in the process of reasoning? What is perception? What is judgment? What are propositions? What is reasoning, or argumentation? What is a syllogism, or regular argument? What is disposition? What is a theme? What is a substance? What are modes? How do we obtain the knowledge of substances? What are essential modes? What are accidental modes? What are modes of other modes? What are sensible ideas? What are intellectual ideas? What are abstract ideas? What is abstraction? What is comparison?

CHAP. XLII.

PNEUMATOLOGY—continued.

LOGIC.

Definition is the exact determining of the nature of a complex idea, by pointing out the chief simple ideas of which it is composed.

Definitions are either nominal, that is, definitions of names; or real, that is, definitions of things.

Nominal definition, explains what any word means; and real definition, explains the thing expressed by the word. The former guards against the confusion which the inaccurate or improper use of words introduces; the latter tends to prevent the confusion which is the result of ideas improperly intermingled.

A definition, in order to be good and accurate, must be, first, Universal, or adequate; that is, it must be applicable to all the particular species or individuals which are included under the same idea. Thus the definition of the word wine, should comprehend and be applicable to every species of liquor to which that name is given.

Secondly, In order to be accurate, a definition should be proper and peculiar to the thing defined, so as to distinguish it clearly from all other things.

Thirdly, A definition ought to be clear and plain; none of its terms must be doubtful, equivocal or obscure.

Fourthly, A definition should be short; it should have no superfluous words.

Fifthly, Neither the thing defined, nor any mere synonymous term, should be found in the definition.

When the mind has obtained ideas by sensation, reflection, and their combined operation, it proceeds to compare them together, to connect them by affirmation, or to disjoin them by negation, according as it finds them to agree or to disagree. This act of the mind is called judgment. Thus the ideas, Plato, philosopher, Nero, tyrant, are connected by the judgment; Plato was a philosopher; Nero was a tyrant; and the ideas sinner and happy, iron and soft, are disconnected; as the sinner is not happy; iron is not soft. The effect of judgment is a proposition; and this is composed of three members, the subject, the predicate, and the copula.

The subject of a proposition, is that concerning which an affirmation or negation is made. Thus in the proposition, " Every angle is formed by the meeting of two lines;" angle is the subject.

The predicate, is that which is affirmed or denied of the subject; thus, " formed by two lines meeting," is the predicate of that proposition.

The subject and predicate of a proposition taken together, are called its matter; for these are the materials of which it is framed.

The copula is the form of the proposition, or the sign of connection or disconnection between the subject and the predicate. Thus the copula of the foregoing proposition is the affirmative, " is."

Propositions are of different kinds, according to their subject, their predicate, their composition, their sense, and their evidence.

Propositions, according to their subject, are universal, or particular.

A proposition is universal, when the subject is taken in its full extent; so that if the subject be a genus, it includes all its species or kinds; and if the subject be a species, it comprehends all its individuals.

The words, " all, every, no, none," and the like, are the common signs of this universality.

A proposition is particular, when the subject is not taken according to its whole extension; but is restrained or limited to some particular species, or individuals.

The signs of this particularity are the words "some, many, few," and similar expressions.

An affirmative proposition, is that in which the idea of its predicate is supposed to agree to the idea of the subject, and is consequently joined to it by the copula, "is," or "are;" as, "All men are sinners." "Virtue is happiness."

A negative proposition separates the subject from the predicate, and denies their agreement, as, "water is not hard."

Propositions are true or false.

A true proposition represents things as they are in themselves, or unites ideas which agree; as, "God is love." "Men are imperfect creatures."

A false proposition joins those ideas or terms whose objects disagree, or it disjoins those whose objects agree; as, "Virtue is misery." "To be good is not to be happy."

Propositions are certain or dubious.

When the evidence of the agreement or the disagreement of the ideas is so plain and strong, that assent cannot be withheld or delayed, the proposition by which the ideas are connected is called certain; as, "Every circle has a centre." "No creature could create itself." Assent to such propositions is honoured with the name of knowledge. But when there is any obscurity resting on the agreement or disagreement of the ideas, so that the mind does not clearly perceive it, and is not compelled to assent or dissent, the proposition is then called uncertain or doubtful;

as, "The sun is an inhabited world." "The earth will not exist a thousand years longer." Such uncertain propositions are called opinions.

When a proposition may be proved by an uninterrupted chain of argument, it is said to be demonstrable; as, "Any two angles of a triangle taken together, are greater than the third."

A series of connected propositions, beginning from some self-evident truth, and proceeding to remoter truths, is called demonstration. Thus mathematical demonstration begins with definitions, advances to axioms, or self-evident propositions, and ends in remoter truths.

Corollaries are deductions made from truths demonstrated before.

QUESTIONS.

What is definition? What are nominal definitions? What are real definitions? What are the characteristics of a good and accurate definition? What is judgment? What is a proposition? What are the three members of a proposition? What is the subject, the predicate, the copula, of a proposition? What is a universal proposition? What is a particular proposition? What is an affirmative, and what is a negative proposition? What is a true, and what is a false proposition? What is a certain, and what is a doubtful proposition? What is a demonstrable proposition? What is a demonstration? What are axioms? What are corollaries?

CHAP. XLIII.

PNEUMATOLOGY — continued.

LOGIC.

There are various ways by which truth is admitted into the mind, and by which various kinds of knowledge are produced. Such are, Sense, Consciousness, Intelligence, Reason, Faith, Inspiration.

When we frame any proposition according to impressions conveyed by either of our senses, we acknowledge the evidence of sense. Such propositions may be named Sensible Propositions, or Dictates of Sense.

Upon this evidence of sense we know and believe the daily occurrences of human life.

By Consciousness we become acquainted with what is passing in our own minds.

Intelligence relates principally to those abstracted propositions which carry their own evidence with them; and is founded upon Axioms.

Reasoning is when one truth is inferred from others by natural and just conclusions; as when if it be light at midnight, we infer that the moon is shining, because we know that the spot on the earth's surface which we inhabit is at that time turned from the sun, and cannot receive light directly from that luminary; or, as when we see a house in a lonely place, we conclude that man has been there. Propositions admitted upon this kind of evidence are called Rational Truths, or Conclusions, and the knowledge which we obtain by this means, is properly called Science.

When we derive the evidence of any proposition from the testimony of others, it is called the Evidence of Faith.

This constitutes a very large part of our knowledge. Upon this kind of evidence we believe the various events recorded by history, and by this, most of the transactions of human society are carried on.

Inspiration is a sort of evidence distinguished from all the former. It is when such an overpowering impression of the truth of certain propositions, is made upon the mind as that it can entertain no doubt on the subject, and is fully convinced that the impression is produced by the immediate operation of the Eternal. But this should be admitted with the greatest caution, and scarcely at all without some external convincing mark or testimony; because the ideas raised or combined by a vivid imagination, may be easily mistaken for divine, supernatural impulses. The propositions grounded on this sort of evidence are called Inspired Truths.

Reasoning is that operation of the mind which joins several propositions together, and makes what is called a Syllogism; that is, an argument by which we deduce something that is less known from truths that are more evident.

If the mere perception and comparison of two ideas would always show whether they agree or disagree, then all rational propositions would be subjects of intelligence, or axioms and first principles. But this is not the case. We are frequently unable to judge of the truth or falsehood of a proposition by the mere contemplation of its subject and predicate, and we are then obliged to use a medium, and to compare each of them to some third idea, that by seeing how far they agree or disagree with it, we may be enabled to judge how far they agree or disagree among themselves.

Suppose two lines, concerning which we wish to know whether they be equal. Let us apply a third line to each of them; and if that agree with each, we justly infer that they are equal; but if it agree with one of them, and not with the other, we then conclude that they are unequal.

Thus, if the question be put, "Is virtue to be admired, loved, and practised?" To determine it, a third idea, "conduciveness to happiness," may be assumed as a common measure, and the case be thus stated; "That which is conducive to happiness is to be admired, loved, and practised; but virtue is conducive to happiness, therefore virtue is to be admired, loved, and practised."

Every Syllogism is constituted of three propositions; called the Major, the Minor, and the Middle.

The proposition which includes the inference is called the Conclusion, and the two preceding ones are named the Premises.

The Major is the predicate of the conclusion connected with the middle term.

The Minor is the subject connected with the middle term.

The Middle term is the third idea introduced and disposed in two propositions, so as to show the connection between the major and the minor. Thus in the Syllogism, "Truth is precious; Christianity is truth, therefore Christianity is precious."—"Precious," is the major, and "Christianity" the minor; "Truth is precious, Christianity is truth," are the premises; and "Therefore Christianity is truth," is the conclusion.

A Conditional or Hypothetical Syllogism is one whose major, or minor, or both, are conditional propositions; as, "If there be a God, the world is governed by his providence: but there is a God; therefore the world is governed by providence."

A Dilemma is an argument which divides the whole into all its parts or members by a disjunctive proposition, and then infers something concerning each part, which is finally inferred concerning the whole; as, "In this life, we must either comply with vicious inclinations, or restrain them: to comply with them will bring sin and sorrow; to resist them, is laborious and painful; therefore we cannot be entirely free from labour and pain in this life."

Analogy is that act of reasoning by which similar effects are deduced from similar causes; as, "All material substances of which we can conceive, have length, breadth, and thickness; therefore length, breadth, and thickness are universal attributes of material substances."

QUESTIONS.

By what various ways is truth admissible into the mind? What is the evidence of sense? What is the effect of consciousness? What is reasoning? What are rational truths, and the knowledge we gain by their means? What is the evidence of faith? What is the evidence of inspiration? What is a syllogism, and what are its parts? What is a conditional, or hypothetical syllogism? What is a dilemma? What is analogy?

CHAP. XLIV.

PNEUMATOLOGY — continued.

LOGIC.

A SOPHISM is an argument which exhibits the appearance of truth, and yet leads to error. It is a false syllogism, where, if the premises be true, there is a fault in the deduction, or else one of the premises is not true, in the sense in which it is used in that argument.

Of sophisms there are various kinds: ignoratio elenchi, or mistake of the question; that is, when something is proved that has no necessary connection, nor in consistency with the object of enquiry, and consequently gives no determination to the enquiry.

Petitio principii, or begging the question, or a supposition of what is not granted, but which is to be proved.

Arguing in a circle; that is, when one of the premises is opposed, to intend to prove it by the conclusion; or when, in a train of syllogisms, an attempt is made to prove the last, by recurring to what was the conclusion of the first.

Non causa pro causâ, or the assigning of a false cause.

Fallacia accidentis, or a sophism in which a conclusion is drawn concerning the nature and essential properties of any subject, according to something that is merely accidental to it.

Sophisms of composition and division.—Sophisms arising from the abuse of the ambiguity of words.

Sophisms of equivocation.— Sophisms of false induction, which infer general theorems and universal propositions from a few inadequate experiments or observations.

Method implies the placing of well-formed propositions, and the disposing of just arguments in such an order as is most convenient to attain some end proposed. This is method in its most extensive sense. But in logic, method is commonly taken in a more limited sense. It is the disposition of a variety of thoughts on any subject, in such order as may best serve to find out unknown truths, to explain and confirm truths that are known, or to fix them in the memory.

Synthetic method is that which begins with the parts, and from them leads on to the knowledge of the whole. It begins with simple principles and general truths, and proceeds, gradually, to that which is drawn from them, or compounded of them, and it is, therefore, called the method of composition.

Analytic method takes the whole as it finds it, whether it be a species or an individual, and leads to the knowledge of it, by resolving it into its first principles, its generic nature, and its special properties; and, therefore, it is called the method of resolution.

If we become acquainted with the structure and springs of a curious complicated machine, by taking it to pieces, we gain that knowledge by analysis; but if we obtain the same knowledge by seeing the maker of it put the machine together, we then acquire that information by the synthetic method.

All arts and sciences have some general subjects belonging to them, which are called topics, or common places, because middle terms are derived from them, and arguments borrowed for the proof of the various propositions of which we have occasion to discourse.

Demonstrations which argue from the cause to the effect, are called demonstrations "a priori."

Demonstrations which argue from the effect to the cause, are called demonstrations "a posteriori."

Arguments are called grammatical, logical, physical, theological, &c. according to the art or science whence they are derived.

Arguments are either certain and evident, or doubtful and merely probable.

Arguments are artificial or inartificial, direct or indirect.

When an argument is taken from the nature of things, and addressed to human reason, it is styled "argumentum ad judicium."

When it is borrowed from convincing testimony, it is named "argumentum ad fidem."

When the argument is drawn from any insufficient medium whatever, and yet the opposer has not skill to refute or answer it, it is styled "argumentum ad ignorantiam."

When the argument is grounded upon the professed principles, or addressed to the particular circumstances and feelings of the person with whom we argue, it is called "argumentum ad hominem."

When the argument is derived from the sentiments of wise and good men, it is, then, "argumentum ad verecundiam."

Finally, when the argument is borrowed from any topics suited to engage the passions of the hearers on the side of the speaker, rather than to convince the judgment, it is "argumentum ad passiones;" and if this take place in a public discourse, it is "argumentum ad populum."

QUESTIONS.

What is a sophism? What are various kinds of sophisms? What does method imply? What is the synthetic method? What is the analytic method? What is a demonstration a priori? What is a demonstration a posteriori? What are certain and doubtful? What is argumentum ad judicium? What is the argumentum ad fidem? Argumentum ad ignorantiam? Ad hominem? Ad verecundiam? Ad passiones?

CHAP. XLV.

LITERATURE.

GESTURE—PHYSIOGNOMY—ELOCUTION.

When sensations are conveyed to the human mind; when ideas are raised and arranged therein; when perception, reflection, judgment, memory, reasoning, have performed their several parts, the results of those internal operations are expressed by external marks and signs, and are thus communicated to others.

The first signs of intellectual operations are Gesture and Physiognomy.

Gesture is action and movement of the limbs and trunk, expressive of the internal sentiment. Strong mental emotions produce corresponding movements of the body. Admiration naturally raises the hands and arms. Fear causes a collapse, or shrinking in, of the whole body. Different passions produce different positions of the head. Humility, shame, sorrow, bend it forwards. Languor and pity press it to one side. Pride elevates it; obstinacy keeps it upright and fixed; astonishment throws it backward; indignation and mockery cause it to make repeated movements from one side to the other.

Gesture, appropriate action, was diligently studied by ancient orators, was universally in high repute, and contributed to the wonderful effects which their eloquence frequently produced.

Physiognomy is the expression of mental operations by the features of the face, the general cast of countenance, and changes of colour. Anger, pride, joy, diffuse a blush over the countenance, while fear and sorrow overspread it with paleness. Terror wrinkles the forehead, raises the eyebrows, and opens wide the eyelids. Scorn and contempt elevate the nostrils. The long indulgence of a particular propensity, the general prevalence of any particular passion, will produce a particular disposition of features, indicative of the inward state.

Physiognomy, by accurate observation, is reduced to regular principles, and is become a kind of science; though it has, perhaps, been carried too far by Lavater, the illustrious Swiss philosopher.

Inarticulate sounds were, probably, the next expressions of mental operations. As many animals, incapable of uttering articulate sounds, utter cries and sounds expressive of their sensations, so man naturally expresses certain feelings by certain inarticulate sounds. Pleasure, pain, grief, joy, fear, are frequently thus expressed. Such is the cry which a man would send forth to warn his friend from going into a place, where he himself had been frightened, or exposed to imminent danger; and the sounds which, together with a peculiar contortion of features, constitutes what we call laughter. Such exclamations, named by grammarians interjections, were undoubtedly the first elements or beginnings of speech.

From inarticulate sounds, men advanced to articulate sounds; sounds formed into words or language. When more extensive communication took place among mankind, it became necessary to give names to objects, to designate them by certain sounds, which were probably, at first, simple; whence must soon have proceeded combinations of two, three, or more sounds.

The earliest application of particular sounds to denote particular objects, may have been guided by some supposed similarity between the several sounds, and the things pointed out by them. Soft or harsh sounds were used to express soft or hard objects. Very frequently the sounds employed to designate animals, or to describe noise and movement, were borrowed from the common cry of the animal, or the noise produced by the motion, concerning which the communication of ideas was made. In all languages many words occur, founded evidently upon this principle of imitation.

Thus the bird named cuckoo plainly has its name from the two sounds which it habitually utters. When one kind of wind is said to whistle, and another to roar; when we speak of the hissing of a serpent, the buzzing of a fly, the crashing of falling timber, the flowing of a stream, the rattling of hail, the clashing together of metallic weapons, the analogy is plainly discernible. But this principle of a natural relation between words and their objects, can be applied to language in its most simple and primitive state only. As the multitude of words increased, and the immense field of language was gradually filled up, words, by many fanciful and irregular methods of derivation and composition, came to deviate widely from their primitive character, and to lose all resemblance in sound to the things signified. In this state language now is; so that words, as they are now employed, may, in general, be regarded rather as symbols than imitations, as arbitrary, not natural, signs of ideas.

Thus, in the early state of language, men endeavoured to communicate their mental ideas and feelings to one another by expressive cries and gestures, and when names of objects were invented, those natural signs could not have been disused suddenly. The small stock of words which men must have had at first, required the aid of exclamations and gestures, to assist in conveying their meaning. Thus we find that significative actions accompanied words in ancient times.

The prophet Jeremiah, when he was delivering the awful warnings of the Eternal to the children of Judah, broke the potter's vessel in sight of the people, threw the book into the Euphrates, put on bonds and yokes, and carried out from the house his household furniture. And thus, among the savage American tribes, in modern times, their speakers, upon all great occasions, joined expressive motions and actions to their orations; such as giving belts of wampum, smoking the calumet or pipe of peace, burying the tomahawk or war hatchet.

Upon articulate sounds depend elocution, declamation, and common conversation.

Elocution is the proper uttering of words, as to inflection or varying of tones; to emphasis, or speaking peculiarly significant words with greater force than others; and to distinct articulation, or sounding clearly the letters and syllables of which words and sentences are composed.

Declamation is proper utterance, accompanied by proper gesture. The combination of these, forms what is called delivery. The Greeks and the Romans carried this to a very great height. The declamation of their orators approached to the nature of recitative in music, and was capable of being marked by notes, and supported by instruments.

Gesticulation, also, was studied as an art. Strong, varied tones, and animated gestures, almost always accompany each other.

QUESTIONS.

What are the first signs of intellectual operations? What is gesture? What is physiognomy? What are inarticulate sounds? What are those exclamations called by grammarians? What are articulate sounds? Whence were the names of objects, probably, first derived? What is elocution? What is declamation? How did men, in ancient times, enforce what they spoke? By what actions did the native American tribes accompany their harangues upon important occasions?

CHAP. XLVI.

LITERATURE — continued.

WRITING.

Men were not contented with the capability of communicating their thoughts to one another, when present, by spoken language; they proceeded to the invention of inscribed figures and written marks, by which they might convey their ideas and feelings to others, when absent, and transmit them even to the latest posterity.

The first marks of this kind were, most probably, pictures, rude resemblances of the objects required to be described to persons at a distance. Thus, the envoys whom the Mexican emperor Montezuma sent to the Spaniards upon their arrival on his coast, depicted on cotton the horses, the men, the ships, the fire and smoke of the guns. But as this mode was soon found cumbersome and inconvenient, parts of figures and objects were substituted to wholes, and these, gradually, became characters for things.

These characters or marks were called hieroglyphics. They were often suggested by imagined similarity of properties. Thus, a serpent was the emblem of cunning; the viper, of ingratitude; the fly, of imprudence; the dove, of meekness; the stork, of filial affection; the hawk, of victory; the ant, of wisdom; the owl, of contemplation; the human eye, of foresight and providence; a snake with his tail in his mouth, of eternity. This was called symbolical, or emblematical writing.

Many of the ancient, especially the eastern nations, made use of characters of this kind, and the Chinese letters are much of this nature at present. The Chinese have no simple sounds which compose their words, but every single character is significant of an idea.

Hieroglyphics, or symbols, were, therefore, a more refined and extensive species of painting. Pictures delineated the resemblance of external visible objects. Hieroglyphics described invisible objects, by analogies taken from the external world.

The characters for numbers which we now use, and which were derived from the Arabians, are a kind of hieroglyphics. Like the Chinese characters, they are signs of things, not of words.

In process of time marks for sounds, instead of marks for ideas and things, were happily invented, which remedied the imperfection, the ambiguity, and tediousness of hieroglyphical and symbolical writing. The first step in this important process was the invention of characters for syllables, or combined sounds; and such are said to be still retained in Ethiopia, and in some parts of India. This greatly reduced the number of characters necessary for writing, but the number of them must have been still so great, as to have rendered both reading and writing tedious and difficult.

At length, however, the sounds of the human voice were traced to their simplest elements, and reduced to a very few vowels and consonants, each represented by a particular character or sign. By the combinations of these signs, all the various combinations of sounds, called words, which are used in speech, are committed to writing.

A complete set of these characters is called an alphabet, and this kind of writing is called alphabetical writing.

To whom this admirable and most useful invention is to be attributed, is not known. It is said to have been brought into Greece by Cadmus, a Phenician, who was contemporary with Joshua; but it is most probable that the alphabetical characters had their origin in Egypt. The alphabet, which was introduced into Greece by Cadmus, had only sixteen letters; the rest were added afterwards, as signs, for proper sounds were found to be wanting.

The letters were originally written from the right towards the left hand, exactly contrary to the order we follow at present. Afterwards the Greeks adopted a new method, that of writing their lines alternately from right to left, and from left to right. This arrangement was called Boustrophedon, or writing after the manner in which oxen plough the ground.

At last, the motion of the hand from left to right being found more convenient, was adopted by all the European nations.

Writing was, for a long time, a kind of engraving. For this purpose, pillars, and tablets of stone, were employed, and afterwards plates of lead, leaves and pieces of the bark of trees, and tablets of wood, covered with a thin coat of wax, on which the impressions were made by a rod of iron, called a stylus, having one end pointed for writing, and the other blunted for effacing. In later times the skins of animals, properly prepared, were used for this purpose. Paper was invented in the 14th century.

QUESTIONS.

What were the first marks employed by men to communicate their ideas to one another when at a distance? What were hieroglyphical characters? What people still use characters, representing things and not sounds? What is alphabetical writing? Whence is it probable that alphabetical characters were invented? Who brought the alphabet into Greece?

Of how many letters did the alphabet of Cadmus consist? How were the characters ranged at first in writing? What was the manner of writing called Boustrophedon? Upon what substances were the alphabetical marks first inscribed, and with what instrument? When was paper invented?

CHAP. XLVII.

LITERATURE — continued.

GRAMMAR.

GRAMMAR is that science which treats of the construction of language, and which gives rules for speaking and writing with propriety.

The rules of Grammar are deduced partly from established practice, and partly from philosophical reasoning.

General, or universal Grammar, lays down those principles and rules which are common to all languages.

Particular Grammar teaches the rules peculiar to any particular language. The proper classification of the words of which language is composed, is the first object of Grammar. This is usually called the division into parts of speech.

Letters, characters for simple sounds, form syllables, or combined sounds. Letters which have a distinct sound of themselves are called vowels. Letters which have not a distinct sound by themselves, are named consonants.

Syllables form words. Words form sentences.

The expressing words by their proper letters and syllables is called spelling.

The essential parts of speech are the same in all languages. In all languages there must be some words, names of things, which words are called nouns, or substantives; some words expressing the qualities and properties of the things named, and these are called adjectives; others signifying being or action, which are called verbs; others expressing the connections and dependencies which take place among things or objects of discourse, such are conjunctions and prepositions; some words to express the time, place, and manner of actions, these are named adverbs.

To all these, convenience has added words called pronouns, expressive of person, and to prevent the too frequent repetition of nouns; and other words named articles, to single out individuals, of which we wish to speak, from the common herd.

Of nouns or substantives, some express species or classes of things, as mineral, vegetable, animal, stone, tree, man; and such are called common nouns. Others signify individuals of species or classes, and they are called proper nouns.

Common substantives convey the ideas of whole species or classes of objects, as mineral, vegetable, animal, man, lion, tree; but it was necessary, also, for carrying on discourse, to determine which mineral, vegetable, animal, man, lion, or tree, among the numbers comprehended under one name, was designated. To effect this, the article was invented. Articles, therefore, are words of great use in language.

Besides this quality of being particularised by the article, nouns substantives are affected by three circumstances, number, gender, and case.

Number distinguishes substantives as signifying one, or more than one, of the things of which they are the names. When in that state in which they express one object only, the substantives are said to be in the singular number; when in that which bespeaks more than one, they are said to be in the plural number.

This is a distinction found in all languages, and which must have been established in the very infancy of language, since men must always have had occasion for some method of distinguishing between one and many. For this purpose the plural has in all languages been marked by some variation made upon the substantive noun. In the Hebrew, the Greek, and some other languages, there is, also, a change in the substantive, to express "two;" and this is called the dual number, which probably took its rise in early times, from the want of separate terms of numbering, one, two, and many being then the chief numeral distinctions which were known or required.

Gender is an affection of substantive nouns, founded on the distinction of sex. In a literal and strictly proper sense, therefore, gender can find place only in the names of animals; all other substantives ought to belong to what the grammarians call the neuter gender. But in most languages a great number of inanimate objects are ranked under the like distinctions of masculine and feminine.

In some languages, such as the French and Italian, the neuter gender is unknown; so that all the names of things without life are ranged in the masculine or feminine class.

In the Greek and Latin languages, many of the inanimate objects were placed, as they all should have been, under the neuter gender, though a very large proportion of them were graced with the attributes of male and female.

In this respect the English language possesses a decided superiority, by making, in common discourse at least, all inanimate things to be of the neuter gender; yet the genius of the language permits the use of the masculine or feminine gender in a metaphorical sense, to give life and beauty to discourses which require such ornament. The distinction of gender is almost universally expressed by some variation in the state of the substantives.

Case is an expression of the relation which one object bears to another, denoted by some variation introduced with respect to the name of that object; most commonly in the final letters, sometimes in the initial letter, or by prepositions prefixed.

The Greek, the Latin, and several other languages, use declension, or change of certain letters of substantives. The English, French, and Italian do not use declension, or, at most, use it very imperfectly, expressing the relations of substantives to one another by prepositions.

English nouns have no case, excepting a kind of genitive, commonly formed by the addition of the letter *s* to the noun, with an apostrophe (')

between them. The English personal pronouns have a case which answers to the accusative of the Latin. Example: Sing. I, me; Plur. We, us. Sing. He, him; Plur. They, them, &c.

The relative pronoun "who," is declined likewise: Nom. Who; Gen. Whose; Accus. Whom.

Pronouns are of such a particular and artificial nature, that they can hardly be considered as an early invention. They are, at once, the most general and the most particular words in language. They are so general, that they may be applied to all persons and objects whatever, in certain circumstances, and yet they do not denote more than one precise individual.

Adjectives are found in all languages, and in all languages must have been early invented, since calling of objects by names must have been quickly followed by using words to express their qualities.

In the Greek and Latin languages the same form of declension is given to the adjectives as to the substantives. The termination of adjectives is changed, in order to express higher degrees of properties and qualities, and according to the gender and number of the substantives to which they belong.

English adjectives have no change of termination, but to raise qualities higher, and such a change is called comparison.

The French, Italian, and other languages, change the termination of adjectives, according as their substantives are in the plural number, and of the masculine or feminine gender.

The verb, like the adjective, expresses an attribute, or property, of some person or thing; but it goes still farther; it expresses action and time likewise. There can be no complete sentence or proposition without a verb expressed or implied.

Tense is an affection of the verb contrived to point out the time of the action's taking place.

The past, the present, and the future, are the three divisions of time which first present themselves to the mind, and it might be thought sufficient that, by certain changes, verbs should express these three principal parts of time. Language contents not herself with this, but uses numerous tenses to indicate the different shades and minute subdivisions of time.

These tenses are formed, sometimes by changes in the final letters, sometimes by other verbs added, and for that reason called auxiliary verbs.

Besides tenses, verbs admit the distinction of active and passive voice, according as action or suffering is denoted. This distinction is expressed, also, by change of termination, or by added words.

The distinction of moods, designed to express the affirmation, whether active or passive, under different forms, is, likewise, an affection of verbs. A mood, called the indicative, simply affirms a proposition; another mood, styled the subjunctive, expresses the proposition, subject to some condition.

The imperative mood betokens command.

The infinitive mood may be called the name of the verb. It carries neither time nor affirmation, but merely expresses that attribute, action, or state of things, which constitutes the subject of the other moods, and of the tenses. It is accordingly often regarded as a substantive.

To verbs belong also words called participles, which are, in fact, a kind of adjectives.

Verbs admit of a change of termination likewise, indicating the person. Excepting the pronouns of the first and second person, all other subjects of verbs are in the third person.

Verbs that require objects as well as subjects are called transitive verbs. Verbs that have no objects, are called intransitive verbs.

Adverbs form a very numerous class of words in all languages, and may, generally speaking, be ranked in the class of affirmatives, as they denote circumstances of action or qualities, relative to time or place, order or degree.

Prepositions and conjunctions belong to the class of words called connectives.

Conjunctions are commonly employed for connecting sentences, or members of sentences.

Prepositions connect words, by showing the relations which exist between them.

Hence it is plain, that conjunctions and prepositions are of high importance in language, since they are its connecting bands.

QUESTIONS.

What is grammar? What is universal, and what is particular grammar? What is the first object of grammar? What are the elements of sentences? What are the elements of words? What are vowels and consonants? What is spelling? What are substantives? Adjectives? Verbs? Conjunctions and prepositions? Pronouns? Articles? Adverbs? What are substantives common and proper? What is declension? How are number, case, and gender expressed? What advantage does the English language possess with respect to gender? What cases have English nouns? What cases have English pronouns? What is the difference between the ancient and modern method of declining substantives? Why are the terminations of adjectives changed? On what account do English adjectives change their terminations? What affections belong to verbs? What is tense? Person? Mood? What are participles?

CHAP. XLVIII.

LITERATURE — continued.

SYNTAX.

Syntax is that arrangement of words in a sentence, which renders the meaning of each word, and the relation of all the words to one another, most clear and intelligible.

In every language there are rules of syntax, which must be inviolably observed by all who wish to speak or write with propriety.

The fundamental rules of syntax belong equally to all languages, for in all languages the parts of speech are essentially the same; and wherever these parts of speech are found, there must be certain relations among them, the regulation of which constitutes syntax.

The word syntax is derived from a Greek term, signifying the placing together in order.

A sentence is a number of words so put together as to form complete sense, or express a proposition.

The subject, the attribute, and the object, are the principal parts of a sentence.

The subject is the thing, concerning which an affirmation or denial is made, and is always the nominative case to some verb.

The attribute is what is affirmed or denied.

The object is the thing affected by the action expressed by some verb, and is its accusative case.

Example.—"God blesseth the righteous." "God" is the subject; "blesseth" is the attribute; "the righteous" the object.

Concord is the proper agreement of words with one another, which agreement consists in number, person, case, and gender.

Government is the operation of one part of speech upon another, as to tense, mood, or case.

The chief rules of syntax are as follows.

1st. The verb agrees with its nominative case in number and person.

Example.—"The sun shines. The clouds disperse. I consent. He rejoices."

2. Two or more substantives joined by a copulative, though they may be in the singular number, yet require the verbs or pronoun, to which they refer, to be in the plural number, otherwise their common relation to the verb or pronoun is not pointed out.

Example.—"The man, the woman, and the child, were objects of universal pity."

3. Substantives singular, dissevered by disjunctions, will have the verb singular.

Example.—"Neither his father nor mother, nor uncle nor aunt, was present on that occasion."

4. An active or transitive verb must govern the accusative; that is, must clearly point out some substantive noun, as the object upon which it acts.

Example.—"The Lord searcheth the heart, and trieth the thoughts."

5. A relative pronoun must, in every form of speech, agree with its antecedent in gender, number, and person.

Examples.—"I am he who performed that action. Thou art the man whom I esteem and love."

6. Conjunctions, or connecting words, ought always to couple like moods and cases; that is, should join together words which are of the same form and state.

Example.—"He feared, loved, and served God all the days of his life. On me, and you, and him, fell the whole weight of that severe calamity."

7. Every adjective belongs to some substantive expressed or understood.

Example.—"The wicked (wicked persons) are miserable.

8. When two substantives come together, signifying different things, the one must govern the other in the possessive or genitive case.

Example.—"Solomon's wisdom; Daniel's piety."

9. When two verbs come together without a nominative case between them, the one is governed by the other in the infinitive mood.

Example.—“She runs to meet him. She loves to assist her father.”

10. Participles govern like cases with the verbs from which they are derived.

Example.—“I am hopeless of benefiting him by good advice.”

11. Prepositions govern the objective case.

Examples.—“Do that kindness for me. He went with me from London to Dover.”

QUESTIONS.

What is syntax? Why do the fundamental rules of syntax belong equally to all languages? Whence is the word syntax derived? What is a sentence, and what are the principal parts of a sentence? What is the subject? What is the attribute? What is the object? What is concord? What is government? What is the rule of concord between the verb and the nominative case? In what state do two or more substantives singular, connected by a copulative, govern the verb? In what state is the verb governed by two or more substantives singular, dissevered by disjunctions? In what case does the verb transitive govern the substantive? How does the relative pronoun agree with its antecedent? What moods and cases do conjunctions couple? What is the connection between adjectives and substantives? When two substantives come together, of different significations, how do they govern each other? When two verbs come together, without a nominative case between them, how do they govern each other? What government have participles? What government have prepositions?

CHAP. XLIX.

LITERATURE—continued.

PRINCIPLES OF COMPOSITION—RHETORIC—ORATORY.

RHETORIC and Oratory are regarded, by many authors, as terms of exactly the same meaning. If there be any difference, Rhetoric seems to refer principally to the proper arrangement of words for the communication of thoughts by writing; while Oratory respects rather the arrangement of words, for the clear conveyance of ideas, by discourse or public speaking. Both are included in the expression, Principles of Composition.

The business of Rhetoric or Oratory is the giving of rules and directions for writing, and for speaking well.

For writing or speaking to be so conducted as to answer its desired ends, instruction and persuasion, according to Cicero, the illustrious Roman orator, it must be done justly, methodically, floridly, and copiously.

To write or speak justly, it is necessary that the writer or speaker be master of his subject, so as to be able to express all the sentiments naturally belonging to it, and to avoid whatever may appear foreign to it, or trifling.

To write or speak methodically, requires that all the parts of a discourse be placed in proper order, and in such connection as to reflect light upon one another, so as to render the whole clear and easy to be retained.

To write or speak floridly, is to use skilfully the beauties and flowers of language, so as to adorn, and render attractive, the subject, without inducing obscurity by false ornament.

To write or speak copiously, is to have a proper manner of enlargement, suited to the nature of the subject; to delineate the images of things in their full proportion; to paint them in their proper colours; to place them in clear light; to represent them in different views, so as to give pleasure, to engage attention, to move and persuade.

The first requisite for this, is the formation of a good style.

Style is the peculiar manner in which a man expresses his thoughts, by means of language; so that style is different from mere language, or words. Style has always some reference to the author's manner of thinking; it is a kind of picture of the ideas which rise in his mind, and of the manner in which they rise. Hence writers of different nations have been distinguished by peculiarities of style, adapted to the genius and habits of those nations. Perspicuity and ornament are the chief requisites of a good style.

Perspicuity requires purity, propriety, and precision, in single words and phrases.

Purity is the use of those words and phrases only, which belong to the idiom of the language in which the discourse is written or spoken.

Propriety is the selection of such words in the language, as the best and most established usage has appropriated to those ideas intended to be expressed by them.

Precision is the removing of all superfluities from expressions, so as that they may exhibit neither more nor less than the ideas they are meant to convey.

Ornament consists in the graceful, strong, melodious construction of words, and in the proper use of figurative language.

Oratory consists of four parts: invention, disposition, elocution, and pronunciation.

Invention is the finding of such thoughts as may seem most proper to explain and enforce the subject of discourse.

Disposition is the arranging of those thoughts which may have occurred to the mind, in such a manner, that they may appear in the most striking point of view, and not lose any of their force by disorder and confusion.

Elocution is the giving the thoughts a pleasing dress, by harmonious periods, and other ornaments of style, and thus to brighten the discourse.

Pronunciation is the proper, impressive, and pleasing delivery of the discourse.

This was the ancient division; but elocution is now generally considered as being the delivery of the discourse; comprehending pronunciation, inflection, emphasis, and appropriate gestures.

The principal parts of a regular discourse, are, the exordium, or introduction; the proposition, or enumeration of the subject; the narration, or explication; the argumentative part; the pathetic part; the peroration, or conclusion.

For the proper conduct of each of these parts, excellent rules have been laid down by ancient and modern rhetoricians.

The principal kinds of rhetorical composition are, the demonstrative, the deliberative, the judicial.

The demonstrative discourse proves, praises, censures, and comprehends funeral orations.

The deliberative comprehends all subjects relating to government and civil polity, and had, at one time, great extent and influence in the ancient republics.

The judicial form includes all law proceedings, civil and criminal, including both attack and defence of person and property.

Figures of speech, in general, may be described to be that language which is prompted by the imagination, or by the passions.

Rhetoricians usually divide them into figures of words, and figures of thoughts.

Figures of words are called tropes, because they consist in employing words in a signification different from their original meaning.

Figures of thoughts use words in their primitive signification, and the change takes place in the turn of thought, as is the case in exclamations, interrogations, apostrophes, and comparisons.

Metaphor is a figure founded entirely on the resemblance which one object bears to another.

Example. — " If it be said of a good and patriotic sovereign, ' he is like a father to his people,' it is a comparison, or simile; but if it be said, ' he is the father of his people,' it is a metaphor, for the comparison is only insinuated, and not expressed."

Allegory is a continued metaphor. Example:

" He rush'd upon them, as the furious wave,
Swoln by the cloud-borne tempest, falls amain
On some swift ship, and hides her all in foam.
Amid the shrouds the roaring blasts resound,
And the poor sailors view with trembling hearts
The near approach of death." Hom. *Iliad.*

Hyperbole, or exaggeration, consists in magnifying an object beyond its natural bounds. Example:

" She poured forth tears at such a lavish rate,
That were the world on fire, they might have drown'd
The wrath of heav'n, and quench'd the mighty ruin."
Lee.

Personification, or prosopopeia, is the attributing of life and its properties to inanimate beings. Examples:

" O woods, O mountains, hear my plaintive cries!
The thirsty earth drinks in the falling showers;
Earth smiles around with boundless plenty blest.
But yonder comes the powerful king of day,
Rejoicing in the east."

Apostrophe is an address to a real person, but one who is either dead or absent.

Example. — " O brother, most dear to my heart, though immature and unmerited death hath swept thee from the stage of life, yet art thou rather to be congratulated than pitied; for with thy life thou hast lost, not a kingdom, but flight, exile, poverty, and all those sorrows which press me down under an intolerable burden." Sallust.

Comparison, or simile, is a resemblance between two objects, openly and regularly expressed.

Example.—"As the rain cometh down, and the snow from heaven, and returneth not thither, but watereth the earth, and maketh it bring forth seed for the sower and bread for the eater, so shall the word of the Lord be; it shall not return unto him void.

Antithesis is the setting of two objects in opposition or contrast to each other.

Example.—"Virtue is all loveliness, vice all deformity; virtue deserves all praise, vice all blame; virtue leads to happiness, vice to misery."

Metonomy interchanges the names of things, between which there is some natural, though not necessary, connection.

Example.—"Ceres, the goddess of corn, is sometimes taken for corn itself, Bacchus for wine, Mars for valour."

Irony is a figure which makes an assertion evidently quite contrary to what is really meant.

Example.—"Hast thou actually committed that folly? Oh, thou art a *wise man* indeed!"

Synecdoche is a figure which assumes a part for a whole.

Example.—"A fleet of fifteen sail."

Climax is a gradual rise of one circumstance above another, till the idea be carried to the utmost height. Example:

> "The cloud-capt towers; the gorgeous palaces!
> The solemn temples; the great globe itself."

QUESTIONS.

What are rhetoric and oratory? What is Cicero's rule for the proper conduct of composition? What is style? What are the chief requisites of a good style? What does precision require? In what does ornament consist? What are the four parts of oratory? What is invention? What is disposition? What are elocution and pronunciation? What are the principal parts of a regular discourse? What are demonstrative, deliberative, and judicial discourses? What are figures of speech, and how are they divided by rhetoricians? What is metaphor? Allegory? Hyperbole? Prosopopeia? Apostrophe? Simile? Antithesis? Metonomy? Irony? Synecdoche? Climax?

CHAP. L.

LITERATURE—continued.

HISTORY — CHRONOLOGY.

To record past events for the benefit and instruction of mankind, is the proper end of history. Hence it appears that fidelity, accuracy, and impartiality, are the principal qualities requisite in the historian. Historical composition comprehends History, Annals, Memoirs, Lives.

Regular History may be considered as the general history of the human race; or the history of some state or kingdom; or the history of some particular great event, or some portion or period of time, considered as a whole.

In the management of his subject the historian should attend, first to unity; that is, the so connecting its different parts by some common principle as to render it one, whole, and entire. The historian must endeavour, likewise, to trace events and actions to their sources, and to point out the springs and motives which produced them. In his narration, he must preserve clearness and order, accompanied by becoming gravity, strength, and spirit.

Annals, are commonly supposed to mean a collection of facts, arranged in chronological order; which serve as materials for the more superb structure of history.

Memoirs signify a sort of historical composition; in which the writer does not profess to give full information of all the facts respecting the period of which he is writing, but only to relate certain events which he had the means of knowing, or which he himself actually witnessed.

Biography, or the records of the actions of individuals, is a very useful kind of composition, less stately and formal than history, but scarcely less instructive. It affords the opportunity of seeing the virtues and errors of eminent persons fully displayed, and of beholding them in private life.

The most illustrious historical writers are: among the ancients, Herodotus, styled the father of History, Thucidides, Xenophon, Polybius, Livy, Sallust, Tacitus; among the moderns, Guicciardini, Davila, Bentivoglio, Paul, Strada, Buchanan, Clarendon, Burnet, Hume, Robertson, Gibbon, Mezeray, De Thou, Vertot, Voltaire, Schiller, Sismondi.

Of Memoirs and Annals, Sully and Retz were the most famous writers; and of Biography, Plutarch and Suetonius.

CHRONOLOGY.

With History is intimately connected Chronology, or the science of computing and regulating the periods of time, as measured by the revolutions of the earth and the moon; of reckoning time past; and of arranging properly the various events recorded by the historian. Its most common divisions of time are, hours, days, weeks, months, and years.

Hours are artificial or natural. A natural hour is the twenty-fourth part of a natural day, as shown by a well-regulated clock. An artificial hour is the twelfth part of the artificial day or night.

Days are natural or artificial. A natural day is the portion of time which elapses between the meridian of any place being so situated as to point directly to the centre of the sun, and its coming round again into the same situation. An artificial day is the portion of time which passes between sun-rise and sun-set. The French, the English, the Spaniards, and almost all the European nations, make the artificial day to begin at one midnight and end at the midnight following. In some parts of Germany and Italy, the day is reckoned to begin at sun-set and to end at the sun-set following. The Chaldeans, Syrians, Persians, and Indians begin the day at sun-rise. The Arabians, the ancient Gauls, the Athenians, and most probably the Egyptians, made their day commence at sun-set. The Ausonians, the most ancient inhabitants of Italy, computed their day from midnight. Hipparchus adopted this mode, and Copernicus revived it.

A week is a portion of time consisting of seven days. This division of time is very ancient. It may be traced even to the ancient Chaldeans, and to periods preceding the deluge. It is probably a civil or religious institution; for almost all nations among whom any ideas of religion prevailed, have chosen one or other of those seven days to be devoted to public worship.

A month is a portion of time measured either by the earth's motion round the sun, or by that of the moon about the earth; or including a certain number of days, according to the customs of different countries.

The two former are called astronomical months; the latter, civil or calendar months.

A year is that space of time in which the various changes of seasons, and varieties of days and nights, and the death and revival of the vegetable world take place.

The Romans called this space of time " Annus," or " Circle;" whence the French derive their word, " an," or " année." The Northern nations of Europe called it " Ar," a word signifying the cultivation of the earth; whence was derived the Anglo-Saxon term " Gear," and the English appellation " Year."

Among different nations, the year has differed with respect to its length, and time of commencement. The beginning of the year has been determined by various dates of memorable events;

such as the creation, the deluge, the conjunction of planets, the nativity of our Saviour, and consequently has been referred to different points on the Ecliptic. The Chaldean and Egyptian years were dated from the autumnal; some of the Grecian states made their year begin at the vernal equinox, and others at the summer solstice. The year of Romulus began in March, and that of Numa in January. The Venetians, Florentines, and Pisans, in Italy, and the people of Treves, in Germany, begin the year at the vernal equinox. The ancient clergy dated the beginning of the year from the 25th of March; and this method was observed in Britain, until the introduction of the new style, 1752, since which our year commences on the first of January.

Years have the following varieties:

The Lunar, or the year regulated by the revolutions of the moon; being composed of twelve lunations. But as it was found that the moon performs her course round the earth in twenty-nine days and a half, the lunar months were made to consist of twenty-nine and of thirty days, alternately. Thus the lunar year contained only 354 days.

The ancient Solar year. This consisted of twelve months, of thirty days each, and consequently of 360 days.

The modern Solar year; which consists of 365 days; five days being added to the ancient solar year when astronomers discovered that the sun did not finish his apparent journey through the zodiac in 360 days.

The Bissextile, or Julian year. It being found that the earth, or apparently the sun, took six hours more than 365 days to complete the annual revolution; which, consequently, in four years, made a difference of a natural day; and that through the neglect of reckoning the days thus formed, the year no longer began at the proper time; or else was shorter than it ought to be. The illustrious Roman, Julius Cesar, about forty years before the birth of Christ, employed Sosigenes, an Egyptian astronomer, to remedy this error. Ninety days had been lost, by the omission of reckoning the accumulated days. These were added to the first Julian year, which was thus made to consist of 444 days. The surplus day produced by the six hours in every four years, was introduced into the calendar every fourth year, by counting the 24th of February twice; whence the Julian year was also called Bissextile. This surplus day is now added, every fourth year, to February.

The Julian year was framed upon the supposition that the solar year was exactly 365 days and six hours; but it was discovered afterwards, that of that time eleven minutes were wanting. It was found in 1582, that in consequence of this error, between the time when the Nicene Council was held, A. D. 325, and that date, the Julian year had varied from the true solar year, about ten days. To rectify this inconsistence, Pope Gregory XIII. ordered that ten days should be taken out of the calendar for the current year, and that the 5th of October 1582, should be reckoned to be the 15th.

This reformation of the calendar was called the Gregorian, or New Style. It was not adopted in England till the year 1752, when it was become necessary to strike out of the calendar eleven days.

The Siderial year is the space of time which elapses while the sun appears to be passing from any one fixed star to the same fixed star again.

The Tropical year is the time which the sun appears to take in travelling from either tropic, or from any one point of the ecliptic to the same again.

The Calendar, or Almanack, is a table, wherein are inserted all the days of the year successively, with the festivals and holidays marked in their proper places. This table of days is divided into fifty-two weeks, and one day over, by means of the first seven letters of the alphabet perpetually recurring throughout the year.

The name Almanack, is derived from the Arabic phrase al Manach; that is, the calculation; and the term Calendar, is borrowed from the Roman word, Calendæ.

The letter which stands opposite, in the Calendar, to every Sunday throughout the year, is called the Dominical letter.

Cycles, are spaces or revolutions of time, the most considerable of which are, the solar cycle, twenty-eight years; the lunar cycle, nineteen years; the cycle of the Roman indiction, a period of fifteen years.

The Epact is, the number of days, or the age which the moon has at the beginning of a new year.

QUESTIONS.

What is the office of history? What are the principal qualities requisite in a historian? What divisions are comprehended in historical composition? What is regular history? What is that branch of history called annals? What is that part of history called memoirs? What is biography? Who were the most celebrated historians? Who were the chief writers of annals and memoirs? What is chronology? What are the common divisions of time? What are artificial, and what are natural hours? What is the artificial, and what the natural day? What is a week? What are astronomical and civil months? What is a year? The different times of beginning the year? The lunar year? The ancient solar year? The modern solar year? The Julian year? What reformation was introduced into the calendar by Pope Gregory XIII? What is the siderial year? What is the tropical year? What is the meaning of the terms, almanack and calendar? What is the solar cycle? The lunar cycle? The cycle of Roman indiction? What is the epact?

CHAP. LI.

LITERATURE — continued.

MYTHOLOGY.

Mythology is the fabulous history of the heathen gods and heroes. It is a term derived from the Greek, signifying a discourse concerning fables or fictions.

Idolatry is a term compounded of two Greek words, which signify an image or representation of something, and worship or service, and consequently it means the worship of images or symbols.

Idolatry appears to have arisen in very early ages of the world, in the oriental regions, in Phenicia, and in Egypt, whence it spread into Greece, and the neighbouring islands.

The priests of Egypt, who appear to have engrossed all the learning and knowledge of those primitive periods, were probably the first who modelled the fictitious history of gods and heroes into a regular system. They set up as emblems of superior powers and objects of worship, not only many of the irrational creation, such as the crocodile, the dog, the cat, the cow, the ibis, the wolf, but even some inanimate substances. These were first used as hieroglyphics, and gradually became subjects of superstitious adoration.

The principal personages of the Egyptian mythology were, Osiris, Isis, Horus, Typhon, Serāpis, Anūbis, Harpocrates. Osiris and Typhon appear to have been personifications of the good and evil principle; and Anūbis appears to have been the symbol of Sirius the dog-star, by the rising of which the beneficial inundations of the Nile were supposed to be regulated.

The Hindû mythology rivals that of Egypt in antiquity of origin. It consists of a strange mixture of sublime truth and wild fiction. The books in which it is contained are called the Vedas, from the word Veda in the Sanscreet, or sacred language of the Hindū priests, or Brahmins, signifying to know. The supreme being, named Brahma, is supposed by the Hindū mythology to manifest his power through the medium of his divine spirit, called Vishnu, or Veeshnu, the preserver, the pervader, and narayan, or mover on the waters, who supports the whole course of nature. The divine power, when engaged in creating, is the deity Brahma; and when considered as the destroyer, or rather the changer of forms, he is termed Siva, Seeva, Mahadeva, or Mahadeo. The principal inferior deities of the Hindū mythology are, Ganesa or Pollear, the god of wisdom, depicted with the head of an elephant, the emblem of sagacity and discernment; Menu, or Satyavrata, the lawgiver; Lacksmee, goddess of plenty; Indra, the god of the heavens; Seshanaga, the monarch of Patala, or the infernal regions; Yama, or Yamen, the god of death; Seraswatti, wife of Brahma, patroness of the arts and sciences; Cama, the beautiful god of love.

The Chinese mythology gives the name of Buddha, or Boodha, significative of truth and wisdom, to their supreme god, who appears to be the same as the Vishnu of the Hindûs. It likewise deifies To, or Tohi, the supposed founder or reviver of the Chinese empire; and Confucius, their illustrious philosopher and legislator.

The ancient religion of Iran, or Persia, was, in its origin, pure and rational, and never became so debased as that of most other nations. Fire was considered by it as the emblem of the great First Cause, the all-vivifying principle; and the sacred fire, kindled by concentrated sun-beams, was preserved with the greatest reverence. The priests were called Magi. But the popular religion of the Persians gradually degenerated into the worship of the sun, moon, and other heavenly bodies. The Persian mythology was reformed by

Zeratusht, or Zoroaster, who received instruction from the Brahmins of India. When the Persians became corrupted by idolatry, the chief deities of their mythology were, Ormuzd, or Orosmades, or Oromazes, the supreme creator; Mithras, a personification of the sun, the first production of the power of Orosmades; Ahriman, or Arimanius, the imaginary author of evil; between whom and Orosmades, the author of good, a continual struggle was supposed to be maintained.

The Scythian mythology is supposed to have been the first corruption of patriarchism, or the primitive doctrine. Its chief deity was named Tabiti, the Vesta of later ages; Papeus, the Jupiter of the Greeks, was ranked next; and then Apia, or the Earth. But the god of war was the favourite divinity of the fierce Scythians; to whom they consecrated forests of oak, raised altars of immense magnitude, and sacrificed horses, and human victims.

The Celtic mythology was the religion of the ancient Gauls, Britons, and other Celtic nations. This gave the name of Teutates to the great supreme. Its other deities were, Hesus, the god of war; Dis, the sovereign of the infernal regions; Andate, the goddess of victory. Its religious rites were performed in sacred groves, and were debased by absurd customs, and cruel sacrifices. Its priests were called Druids.

The Scandinavian mythology appears to be a corruption of that of the ancient Scythians, from whom the Scandinavian tribes are supposed to be descended. It was of a fierce and gloomy character. Human victims were frequently offered in sacrifice. Its principal deities were, Odin, the supreme divinity; Irea, his wife; Niorder, god of the winds and seas; Thor, the ruler of the aërial regions, of thunder, lightning, meteors, and storms; Balder, son of Odin, a mild and gentle god; Surtur, prince of the genii of fire; Heimdal, guardian of the heavens.

The Grecian mythology was much more complicated, and comprehended a much greater number of supposed deities than any of the others. Though the Greeks received most of their religious ceremonies, their manner of worship, and their sacrifices from the Eastern nations, yet they augmented very much the multitude of false gods. The lively imagination of the Greeks saw heaven and earth, mountains, forests, and streams, inhabited by supernatural beings.

According to the Grecian mythology, adopted also by the Romans, Cœlus, or Uranus, the personification of heaven, and Vesta Prisca, that of the earth, were the most ancient of the gods. Their sons were Titan and Saturn, or Chronos, time.

Cybele, or Rhea, was the wife of Saturn, who presided over the earth, maintained its productiveness, and was the patroness of towns and cities. Her image was that of a venerable woman, whose head was crowned with turrets; who bore in her hands keys, and a drum or disk. Her temples were round.

Vesta, the supposed daughter of Saturn, was the goddess of fire, emblematical of pure vital heat. A fire, consecrated to her, was annually lighted by the rays of the sun in the beginning of March; and virgin priestesses, called Vestals, were appointed to watch over its preservation, and if they neglected this duty, were buried alive. The worship of this goddess is believed to have been brought into Italy from Phrygia, by Æneas. Janus, the god of prudence and foresight, was another of the Roman divinities. He was regarded as the protector of the public roads, and the inventor of doors. Numa Pompilius erected a temple to this deity, which was kept open in time of war, and shut in time of peace. He was depicted with a double face, and having a wand and a key in his hands.

The other principal divinities of Grecian and Roman mythology were, Jupiter, styled the father of gods and men, the ruler of the air, the master of the thunderbolt, the cloud-compelling god. He was emblematical of the purest air. He was, in all probability, a king of Crete, who was deified on account of his power and famous actions. He was represented under the figure of a majestic man, seated on a throne; holding in his right hand the dreaded thunderbolt; in his left a sceptre, and an image of victory; and near him, an eagle with extended wings.

Juno, his wife and sister, was emblematical of the grosser atmospherical air. She presided over empires and riches, and was particularly regarded as the protectress of married women. She was represented as a handsome majestic woman, having near her Iris the rainbow, and the Peacock her favorite bird.

Ceres, the daughter of Saturn and Rhea, the goddess of corn and agriculture.

Apollo, or the sun, who was supposed to preside over music, medicine, poetry and rhetoric; divination and archery. To him was dedicated the laurel.

Diana, the sister of Apollo, and daughter of Jupiter. She was the goddess of chastity, of woods and of hunting; and was emblematical of the moon. Her magnificent temple at Ephesus, was one of the seven wonders of the world.

Bacchus, son of Jupiter. He was the god of the vine, the inventor of commerce and navigation; who brought men from a savage to a civilized state, and taught them to cultivate the grape and to make wine. He was probably some illustrious hero and sage, deified for his beneficial or splendid deeds. Some supposed him to have been the great Hebrew legislator, Moses.

Minerva, supposed to have sprung from the head of Jupiter, was the goddess of wisdom and deliberate courage; the patroness of the arts.

Mars, a son of Jupiter, was the god of war.

Venus, the goddess of beauty and love, was represented by the poets as springing from the foams of the waves Her attendants were Cupid, the god of love, he mischievous infant son, and the graces.

Vulcan, a son of Jupiter, was the god of fire, the teacher of the art of metallurgy.

Mercury, a son of Jupiter, the god of eloquence, of arts and sciences, and the messenger of Jupiter. He was the inventor of weights and measures, and the conductor of human souls to the regions of futurity.

Neptune, a son of Saturn, was worshipped as the ruler of the waters, the god of the ocean and of maritime affairs, the breaker and traiher of horses.

Pluto, a son of Saturn, was the gloomy god of the infernal regions.

Pan, a son of Jupiter, was the god of the woods, and of shepherds.

Hercules, a son of Jupiter, a deified hero, was the god of strength and valour.

Oreades, were nymphs or goddesses of the mountains; Dryades, of the forests; Nerides, of the waters.

QUESTIONS.

What is mythology? What is idolatry? Where did mythology take its rise? What were the principal divinities of Egyptian mythology? What is the Hindû mythology, and its deities? What is the Chinese mythology? The Persian? The Scythian? The Celtic? The Scandinavian? What were the principal gods of the Grecian and Roman mythology? Who was Coclus? &c. and so on.

CHAP. LII.

LITERATURE — continued.

Expression of ideas by articulate measured sounds, or poetry.

Poetry is defined to be the language of passion, or of enlivened imagination, expressed by bold figures, and formed, most commonly, into regular numbers.

In the early ages of the world, poetry was intimately connected with music, and its recitation was always accompanied by some simple instrument. Being uttered in song, poetry was formed into numbers, or an artificial arrangement of words and syllables, whence arose that great characteristic of poetry, which is called versification. Poetry may be arranged in six classes; pastoral poetry, lyric poetry, didactic poetry, descriptive poetry, epic poetry, dramatic poetry.

Pastoral poetry, celebrates rural scenes and objects, and the simple manners of the ancient shepherd's life. Theocritus, a Sicilian, and Virgil, the Roman poet, were the founders of pastoral poetry.

Lyric poetry. The peculiar character of this poetry is its being intended to be sung, or recited with a musical accompaniment. In lyric poetry, or as it is called, the ode, poetry retains its primitive form, that form in which the ancient bards celebrated the praises of their gods and their heroes, their victories and their calamities.

Of odes, there are four kinds:—

Sacred odes, or odes on religious subjects, and celebrating the perfections of the Supreme. Of this kind of poetry, are the Psalms of David.

Heroic odes, or odes praising the exploits of heroes. Of this kind are all the odes of Pindar, the illustrious Theban, and some of those of Horace, the elegant Roman poet.

Moral and philosophical odes, express sentiments of virtue, morality, and friendship. Many of Horace's odes are of this nature, and some of more modern poets.

Festive odes are adapted merely to enliven and amuse. Such are the odes of Anacreon and some of Horace's.

Didactic poetry. The peculiar province of didactic poetry is, to convey knowledge and instruction, and to render that food of the mind more agreeable, by the charm of versification. Of this kind of poetry, there are many works both ancient and modern, which possess great merit. Such are the poems of Lucretius de Rerum Naturâ; Virgil's Georgics; Pope's Essay on Man, and on Criticism; Akenside's Pleasures of Imagination; Les trois Régnes de l'Abbé Delille.

Descriptive poetry is that, of which description is the basis; but upon which is reared the superstructure of pleasing instruction. Of this kind of poetry, Thompson's Seasons is a beautiful specimen.

Epic poetry. It is the arduous task of Epic poetry, to choose a subject and contrive a story; at once entertaining, interesting, and instructive; to animate this by suitable incidents, to enliven it by variety of character and description, and to maintain propriety of sentiment and elevation of style. Of this kind are, Homer's Iliad; Virgil's Æneid; Milton's Paradise Lost; Lucan's Pharsalia; Tasso's Jerusalem.

Dramatic poetry represents actions as still going on, events still taking place, persons conversing, and expressing sentiments according to their respective situations and characters.

This kind of poetry has two principal divisions: Tragedy and Comedy. Tragedy represents the grave, important and affecting incidents of human life, and rests upon the high passions, the virtues, crimes, and sufferings of mankind.

Comedy represents the lighter incidents of human life, and ridicules the follies and absurdities of men.

The system of rules invented for the proper conducting of versification, is called prosody.

The versification of those nations, whose language and pronunciation were of a musical kind, rested chiefly upon the quantities, that is, the length or shortness of their syllables. This was the case with the Greeks and Romans. Almost every syllable of their language was known to have a fixed and determinate quantity, and their mode of pronouncing it, rendered it so sensible to the ear, that a long syllable was reckoned to be precisely equal to two short syllables. In order to ascertain the regular time of every verse, and the proper mixture and succession of long and short syllables, of which it ought to be composed, were invented what the grammarians called metrical feet, such as dactyls, spondees, iambics, and others.

The accuracy of composition in every line, was tried by these measures. Thus it was required, that the verse called hexameter, should have the quantity of its syllables so disposed, that it could be scanned or measured by six metrical feet, either dactyls or spondees; but with this restriction, that the fifth foot was to be regularly a dactyl, and the last a spondee.

A dactyl is a foot consisting of one long and two short syllables.

A spondee consists of two long syllables.

A trochee is a foot of two syllables; the first of which is long, the second short.

An iambus, or iambic, is a foot of two syllables; of which the first is short, and the second long.

But this measurement of versification is quite foreign to the genius of the English language.

In the poetry of modern languages, the versification depends not so much upon measured feet, as upon rhyme; that is, the making of the terminating syllables of succeeding lines, or of alternate lines, or of lines at certain distances, correspond in sound.

The English language admits a kind of versification, which rejects the fetters of rhyme, and allows the lines to run into each other, fully as much as does the Latin hexameter verse. Therefore, though each line consist of a particular number of syllables, yet it is a noble, bold, and free species of versification, peculiarly adapted to subjects of force and dignity. This is called blank verse.

QUESTIONS.

What is poetry? What is pastoral poetry? What is lyric poetry? How many kinds of odes are there? What is didactic poetry? What is descriptive poetry? What is epic poetry? What is dramatic poety? What is tragedy?

What is comedy? What is prosody? What is a dactyl? What is a spondee? What is a trochee? What is an iambic? What is blank verse? What is rhyme.

CHAP. LIII.

LITERATURE—continued.

MUSIC.

Expression of sentiments by inarticulate measured sounds, or music.

Music appears to have been contemporary with poetry. Man is by nature both a poet and a musician. The same feelings which prompted the enthusiastic poetic style, suggested also certain modulations of sound, adapted to the various emotions of the mind. Music and poetry arose together; they were the offspring of the same passions; they were united in song; they supported and strengthened each other.

The first musical instrument must have been very plain and simple, and so, likewise, must have been the sounds produced from them.

Pipes, a rude kind of flute, and a lyre, with very few strings, were probably known among some nations in the earliest ages; but they were used only to accompany the voice, and to heighten the charms of song.

The bard poured forth his highly-raised feelings in extemporaneous strains of poetry, and accompanied them with accordant sounds from his rudely-fashioned lyre.

The invention of the lyre is ascribed to the Egyptian Hermes, or Mercury.

The single flute, called by the Egyptians photynx, was probably one of the most ancient instruments of music. From various remains of ancient sculpture, it appears to have been shaped like the horn of a bull.

The Grecian lyre, as improved by Apollo, had seven strings, whereas, that of the Egyptian Hermes had but three.

The violin was not brought to the state in which it now is, until the 16th century; before which time it existed under the denomination of the viol, furnished with several more strings, and with frets. The other musical instruments of the present day have been gradually brought to the perfection in which we now see them. Music, vocal and instrumental, constituted a great part of the public worship of the Hebrews, and they seem to have had a variety of instruments, by their different names mentioned. They were principally instruments of percussion, that is, instruments from which the sounds were produced by striking upon them; and as vast numbers of them were touched at the same time, the music must have been very rough and noisy. According to Josephus, there were 200,000 musicians at the dedication of Solomon's temple. The Greeks were extremely fond of music, and it is said to have produced extraordinary effects among them.

The invention of musical characters is attributed to Terpander, a celebrated poet and musician, who flourished about the year 671, before the Christian era.

Before that period, therefore, music must have been entirely traditional, and the transmission of musical compositions must have depended upon memory alone.

Music may be divided into the two branches of melody and harmony.

Melody is the arrangement of sounds, in such succession as to excite pleasurable sensations in the mind.

Harmony is such a union of several sounds, heard at the same time, as excites pleasurable sensations in the mind. Melody is certainly the most ancient, having been known among the earliest nations.

Harmony is, probably, of far later invention. The Greek poets appear, indeed, to have accompanied their recitations with a few plain chords from their lyres; but harmony, as it is now studied and practised, is so complex, that it must have been the result of a gradual process.

A concert is the performance of a number of musical compositions, vocal and instrumental, arranged in due order.

An opera is a dramatic piece, consisting of dialogue and songs; the whole carried on in music, and generally united with dancing.

An oratorio is a sacred musical drama.

A concerto is a musical composition which gives the leading parts, and occasional solos to some particular instruments, supported by the other instruments at proper intervals.

A solo is a composition for a single voice, or instrument; a duet for two; a trio for three; a quartet for four; and so on.

Chromatic melody is that which is composed of several notes in succession, ascending or descending by semi-tones.

The design, or subject, in a musical composition, is some particular air or melody, which the composer contrives to be heard principally throughout the piece.

Fugue is the alternate repetition of the subject in the various parts, treble, tenor, bass.

Treble is the highest part, or class of notes, in a composition; and in vocal music, is generally assigned to women or boys, and expresses the air; the tenor is the middle part; the bass is the lowest, the foundation; the counter-tenor, or alto, is a part assigned to very high male voices, and frequently amounts to a second or under treble.

The principal instruments now in use are, the violin, the tenor violin, the violoncello, and the bass viol, or double bass; stringed instruments.

The flute, the clarionet, the hautbois, the bugle, the French-horn, the trumpet, the bassoon, the trombone, the serpent; wind instruments.

The harpsichord, or piano-forte, gives all the chords of stringed instruments; the organ those of wind instruments.

The treble instruments are, the violin, the flute, the clarionet, and hautbois.

The tenor instruments are, the tenor violin, sometimes the violoncello, the horn, and trumpet.

The bass instruments are, the violoncello, the double bass, bassoon, trombone, serpent, and double-drum.

QUESTIONS.

What is music? What were probably the first musical instruments? When and by whom were musical characters invented? What must have been the character of the Hebrew music? What is melody? What is harmony? What is a concert? What is an opera? What is an oratorio? What is a concerto? What is a solo? A duet? A trio? A quartet? What is a subject? What is a fugue? What is chromatic melody? What are treble, tenor, bass, counter tenor? What are the principal instruments of music now in use? Which are the treble, tenor, and bass instruments.

CHAP. LIV.

EXTERNAL, MECHANICAL EXPRESSIONS OF INTERNAL EMOTIONS.

THE DANCE — DRAWING — SCULPTURE — PRINTING — ENGRAVING — LITHOGRAPHY.

Dancing, as practised at present, may be defined to be " a pleasing graceful movement of the body, adjusted by art, to melody or harmony, vocal or instrumental. But there is a nobler kind of the dance, which expresses the sentiments of the mind, or the passions, by measured steps or bounds, made to the strains of music.

The dance is found to exist more or less, and of one kind or the other, among almost all nations; and as performed by individuals, or by connected numbers, has been used to express joy, grief, rage, terror, festivals, marches, battles, Among the highly polished Greek, dancing was reduced to a regular system, and was arranged in three classes; military dances, domestic dances, mediatorial dances.

Military dances, which tended to confirm bodily activity and strength, were of two kinds, the gymnopedique or dance of children; and the enoplian or pyrrhic, the dance of men armed, and exhibiting the various movements and attitudes of combat.

The domestic dance was that of mere exercise and amusement.

The mediatorial dances were used in expiations, sacrifices and other religious rites.

Many of the savage tribes of Africa and America delight in grand descriptive dances, in which multitudes engage at once. Pantomime, or the description of passions and events by looks, gestures, and actions, may be considered as belonging to the descriptive dance.

Descriptive dancing forms a part of operatical performances.

DRAWING.

Drawing is the art of representing the appearances of objects, upon a plane surface, by means of lines, shades, and shadows, formed with certain materials adapted to the purpose.

Thus drawing transmits, by a representation of figure, the impressions made upon the mind by external objects.

The proper materials for drawing are, black lead pencils; camels' hair pencils, crayons, or pointed slips of black, white and red chalk; Indian ink, crow-quill pens, rule and compasses, Indian rubber. Drawing may be considered as divided into figure-drawing, drawing of flowers, fruits, and shells, and landscape-drawing.

For these different kinds of drawing, a practised eye, a knowledge of proportion in human and other animal bodies, light and shade, perspective, are necessary requisites.

Painting advances beyond drawing by giving colour as well as figure, thus expressing, in a more lively and faithful manner, the ideas raised in the mind by external objects, through the instrumentality of the senses.

A picture of any object, therefore, is the idea of that object transmitted through the mind of the painter, and by his art re-embodied, and represented externally and materially, in its natural form and colours.

Painting was in great repute among the nations of antiquity; and has been found to exist among some of the wildest and rudest of people.

The Greeks appear to have carried this art to the highest degree of excellence; and to have applied it to its noblest purposes, the expression of human passions and feelings, the delineation of human beauty, the representation of interesting scenes, and moving events.

Zeuxis, Parrhasius, Apelles, Protogenes, and Euphranor, were painters of high renown in ancient Greece.

The art of painting was revived in Europe about the end of the 13th or beginning of the 14th century. Leonardo da Vinci, Michael

Angelo, Titian, Raphael, Guido, Caracci, Coreggio; Poussin, Le Brun, Rubens, Salvator Rosa, David, Reynolds, West, Barry, Copland, Porter, Fuseli, Northcote, Smirke, Opie, Bird.

Painting is performed either with water colours, or oil colours.

Sculpture is the art of carving wood, or hewing stone into representations or images, of natural objects. This art is of the highest antiquity. It was practised by the Scythians, the Egyptians, the Phenicians, the Persians, the Etrurians, by the Hindûs, the Chinese, and other eastern Asiatic nations; but it was not brought to perfection, till it became the object of Grecian genius and taste.

The Grecian sculptors represented, with the greatest fidelity, the human form in perfection of beauty and just proportion. Their statues of gods and heroes expressed sublime grandeur and loftiness of conception. Phidias, Polycletus, Scopas, Alcamenes, Myron, Lysippus, were illustrious artists, few of whose works remain to the present day. But by what is seen in the Laocoon, the Apollo Belvidere, the Venus de Medici, the Farnese Hercules, the Niobe, some conception may be formed of their super-eminent excellence.

Clay was the first material employed in statuary. Ivory, silver, and gold were likewise used for this purpose.

The colossal statues of Minerva and Jupiter, the first of which was upwards of forty feet high, and the latter fifty-four, were formed by Phidias of ivory and gold.

But marble was the substance most commonly used by sculptors.

The ancient sculptors generally formed models in wax of the figures they were about to form from stone; and imitating their models, worked with the greatest boldness and precision, clipping the marble with the mallet and chisel.

The modern sculptor commonly forms his model of clay; then having prepared the marble, reducing it to the proper size, he studies the model attentively, and draws upon it horizontal and vertical lines, intersecting each other at right angles. Afterwards, he copies those lines upon his marble, and proceeds to work, directed by them.

PRINTING.

Printing is the art of taking impressions from characters or figures, moveable or immoveable, on paper, linen, silk, or other prepared substances.

There are three kinds of printing.

Common, or letter press printing, for books.

Rolling-press printing from copper plates, for pictures.

Calico printing, for impressing figures on stuffs of various kinds.

The first is performed by moveable letters or words cast in relievo or convex, in distinct pieces.

The second is by figures engraven in creux or hollow concave.

The third is by figures cut in relievo upon blocks of some hard substance, and generally stamped by placing the blocks upon the substances on which the impressions are to be made, and pressing them by percussion or by weight.

To the first of these, letter-press printing, are principally owing the dispersion of the clouds of error; the diffusion of the light of truth, the progress of literature, the revival of the sciences, and numerous improvements in the arts, which, but for this valuable invention, might have been lost to mankind, or would have been known only to a few.

The three cities of Haerlem, Mentz, and Strasburg dispute the honour of this most important discovery.

The first printing seems to have been done by Laurentius at Haerlem in 1430, and was continued by his family. This was effected by separate wooden types. The next printing was carried on with metal types, at first cut, and afterwards cast, at Mentz, but not used in Holland till brought thither in 1472.

It was generally admitted that the art of printing was introduced and first practised in England by Caxton, a citizen of London, about the year 1471. But it appears that a book was published at Oxford in 1468, and that the first printing-press known in Britain, was set up in that illustrious seat of learning.

Two kinds of workmen are employed in the operation of printing, namely, compositors and pressmen.

The compositors arrange and dispose the letters into words, lines, pages, chapters, according to the copy delivered to them.

The pressmen apply ink, made for that particular purpose, to the letters when arranged by the compositors, and take off the impression made by pressure upon paper.

The letters are placed in two wooden frames called cases; each divided into little cells or boxes.

In the upper case are 98 of these, all of the same size, in which are disposed the capitals, small capitals, accented letters, and figures; the capitals being placed in alphabetical order. In the lower case, are 54 cells; and in them are placed the small letters, with the points, spaces, and other marks. Each case is placed in a sloping posture, that the compositor may the more easily reach the upper boxes.

The instrument in which the letters are set, is called a composing-stick, which consists of a long and narrow plate of metal, on the right side of which, rises a ledge that runs through the whole length of the plate, and serves to support the letters, the sides of which are to rest against it. When the compositor has made the complete arrangement of the letters, words, &c. the pressman proceeds to work off impressions, for which business, four things are required, paper, ink, balls, or rollers, and a press.

To prepare the paper for use, it is first wetted by dipping several sheets together in water, which are afterwards laid in a heap, and to make them take the water equally, they are all pressed down by a weight. The ink is made of oil and lamp-black.

The balls by which the ink is applied to the arranged types, are a kind of wooden funnels with handles, the cavities of which are filled, as is also a piece of alum leather, or pelt nailed over the cavity, and made very soft, by being well soaked and rubbed. The pressman takes one of these in each hand, and blackens the letters by beating the balls upon their faces.

The machine by which the sheets of paper are pressed upon the ranges of types covered with the ink, is very complex. When the full number of sheets of which the edition is to consist, has received the impression on one side, the arrangement for the other is laid upon the press, and worked off in the same manner.

The ink used for giving impressions from engraved copper-plates, is a composition made of the stones of peach and apricot stones, the bones of sheep, and ivory, all well burnt, mixed with boiled nut oil, and ground together on a marble slab. In order to print from copper-plates, a small quantity of this ink is taken on a rubber made of linen rags, and with it the whole face of the plate is anointed, as it lies on a grate over a charcoal fire. The plate, when sufficiently inked, is wiped dry with rags, and by the application of the human hand, dipped from time to time in whiting. The plate thus prepared, is laid on the plank of the rolling press, and over it is placed the paper, well moistened, to receive the impression, and over the paper, two or three folds of flannel. The plate, with its furniture, is then, by the operation of the machine, passed between rollers, which pinching very strongly, but equally, press the moistened paper into the strokes of the engraving, whence it absorbs the ink.

Impressions taken in this manner, are called prints, and by means of this, copies of some of the works of the best painters have been multiplied and transmitted to posterity.

Engraving is the art of cutting metals and precious stones, and delineating thereon figures, letters, or some device or design.

Engraving on copper is, the making correspondently to some delineated figure or design, such concave lines on a smooth surface of copper, either by cutting with a sharp tool, or by using some corrosive liquid, as render it capable, when properly charged with any coloured fluid of imparting by compression, to any prepared substance, an exact representation of any figure or design.

Engraving on wood is the most ancient mode.

The first impressions on paper were taken from carved wooden blocks.

Though the ancients practised engraving on gems and crystals, yet the art of engraving on plates of copper and blocks of wood was not known till the middle of the fifteenth century. It is now brought to a very high degree of perfection, so as to give the most accurate and beautiful copies of the works of the most celebrated masters of the art of painting.

Lithography, a term derived from the two greek words signifying "a stone," and "to write," is the art of taking impressions from drawings or writings made on stone.

This was invented by Sennefelder of Munich, about the year 1800.

The lithographic art is founded upon the following principles:—

The facility with which water is imbibed by calcareous stones.

The strong adhesion which exists between resinous or oily substances, and calcareous stones.

The affinity which resinous or oily substances have for one another, and the property they possess of repelling water or any body moistened with water. Hence it results that the tracings made upon the polished surface of a calcareous stone with any resinous or oily substance, adheres so closely to it, that they cannot be removed without employing mechanical means for their separation.

That while the other parts of the stone receive and imbibe the water poured upon it, the water is repelled by the resinous or oily parts.

That when any coloured substance of an oily or resinous nature is passed over the stone thus prepared, the colour will adhere to the resinous tracings, while it will be resisted by the watered parts of the stone.

Thus the process depends entirely upon the watered parts of the stone rejecting the oily coloured matter, and the resinous tracings repelling the water; so that when a sheet of paper is applied to the stone duly prepared, the oily tracings, which alone are coloured, give the impression.

Lithographic engravings are of two kinds; those produced by a simple tracing made upon the stone with a pencil, pen, or crayon, and those produced by the aid of the burin or graving tool, in the same manner as it is done upon copper.

The chemical ink or chalk used in lithography are of a saponaceous quality, and thus have the property of adhering with facility to the stone, and of resisting the action of water. In taking the impression from the stone, a screw-press, a lever-press, or a rolling-press, may be employed.

When the drawing or writing with the chemical ink or chalk is completed, and become perfectly dry, water slightly acidulated with vitriolic acid, is poured over the stone slab. A weak solution of gum-arabic is then applied, which closes the pores of the stone, and keeps it in a proper state of moisture. The stone slab is again well washed with water, and printers' balls, loaded with the daubing ink, are applied to it while it is wet.

The ink being of an oily substance, is repelled by the watered parts of the stone, but received by the drawing, upon which no water will lie. The stone plate is then passed through the press in the usual way; and at each impression, the process of watering, and daubing with ink, is repeated.

Instead, however, of tracing the drawing or writing upon the stone, the original may be first designed on paper with red chalk, and then transferred to the stone, by laying its face flat upon the slab, and rubbing its back with a burnisher. This gives a reversed impression on the stone, so that the print from it will be the same as the drawing.

The lithographic art is attended by many peculiar advantages.

It is greatly superior to all other kinds of engraving in expedition and economy.

QUESTIONS.

What are the different kinds of dancing? What were the dances of the Greeks? What is pantomime? What is drawing? What are the proper materials for drawing? What are the requisites for drawing well? What is painting? What is a picture? Has painting been in repute among mankind? What nation appears to have carried the art of painting to the greatest perfection? What were the names of the painters of highest renown in ancient Greece? When was the art of painting revived in Europe, and who were the most famous of the modern painters? With what kind of colours is painting performed? What is sculpture? Among what nations of antiquity was it practised? What nation excelled in sculpture? Who were the most illustrious Grecian sculptors? What are the materials of sculpture? How do sculptors proceed in their work? What is printing? How many kinds of printing, are there? What benefits have arisen from letter-press printing? What cities claim the honour of the invention? When was printing introduced into England? What kinds of workmen are engaged in the operations of printing and what is their several business? Of what materials is the ink made for taking impressions from engraved copper plates? How is the printing from copper-plates performed? What are impressions from copper-plates called? What is engraving? What is engraving on copper? Which is the most ancient kind of engraving? What is lithography? Upon what principles is lithography founded, and how is it performed? When, and by whom, was lithography invented?

CHAP. LV.

MORALS.

THAT science, which regards the regulation of those actions that arise from mental emotions, or which are prompted by the external signs, expressive of intellectual operations, is called morals, ethics, or moral philosophy.

Moral philosophy may be conveniently divided into three principal branches: — Personal morality, social morality, divine morality. These divisions include the duties owing to ourselves, to our fellow creatures, to our God.

Personal morality lays down rules for the regulation of conduct and actions, as involving the well-being of each individual, separately considered.

With this view, it declares that each individual owes it to himself, to acquire and enjoy the greatest sum of good, and to avoid evil as much as he possibly can, in consistence with the duties he owes to others.

It arranges in several classes the constituent principles of human felicity, and gives a criterion by which to estimate them justly.

Goods of the body, or external senses. Health, strength, agility, hardiness, neatness, and decency.

Goods depending upon exterior social connections. Fame, fortune, civil authority, and power.

Goods of intellect. Genius, taste, knowledge, memory, judgment.

Moral goods of the mind. Command over the appetites and passions, prudence, fortitude, benevolence, piety.

As a criterion for their proper valuation, moral philosophy applies to these constituents of happiness, the following considerations: — Comparative dignity, intensity of pleasure, durability, attainability at all times and places, and indeprivable possessibility.

Applying these characteristics of real good, to the four classes of the supposed elements of human felicity, it places the goods of the body lowest in the scale; next above them, the social goods, then the goods of intellect, and at the highest point, the moral goods of the mind.

Thus personal morality inculcates the government of the passions, and animal appetites; the proper use of the mental faculties in the pursuit of truth, and the acquisition of knowledge; the cultivation of fortitude, humility, resignation, temperance, prudence, industry, cheerfulness, and the necessity of self-knowledge.

Social morality, assuming as a basis the social nature of man, and the necessity of his living in a state of society, builds thereon the fair structure of social duties.

These are: — The duties of children to parents; namely, sincere affection, obedience, respect, gratitude, confidence, kind attention, and support in old age.

The duties of brothers and sisters towards one another; mutual affection, forbearance, good offices, assistance.

The duties of husbands and wives; heartfelt love, perfect confidence and union of interest; affectionate care in health and in sickness, in prosperity and adversity.

The duties of parents to children; love, mildness, patience, subsistence, education.

The duties of friendship; firm attachment, disinterested regard, ready aid. Social morality includes, likewise, the duties owing to fellow members of the same community; such as truth in speech, sincerity in professions, fidelity in keeping engagements, honesty in all transactions of business.

Social morality embraces also patriotism, or that pure love of country, which leads to unwearied exertions for public good, and the sacrifice, if required by circumstances, of personal interests to general welfare. It comprehends submission to lawful authority; due respect to rulers and magistrates; obedience to the laws.

It involves, consequently, political science, political economy, with its branches, legislation and police; political virtue, political prosperity.

Finally, Divine morality.

On account of the excellence of its object, and the importance of the duties that it inculcates, is the most valuable branch of human science. It calls into exercise all the higher powers of our nature, and is what particularly distinguishes man from all other animals inhabiting this globe.

That there is an all-creating, all-supporting, all-ruling and directing Intelligence, is a truth presented to the human mind by every external object, and by every one of its own powers and operations: it shines refulgent through the whole circle of the sciences and arts. No being is capable of producing itself, for were such a capability admitted, this absurdity would follow; that it is possible for a being to act before it exists. Every effect, that is, every thing which begins to be, necessarily implies a cause adequate to its production. There must exist, therefore, an intelligent, a designing, an adequate universal first cause. Next to those truths which are intuitively discerned, or which are discovered by means of the senses, this has been most generally admitted by mankind. If there be an original cause of the whole glorious creation, that cause must be itself uncaused, must be eternal. That first universal cause must likewise be one, since the supposition of more than one *first cause* is evidently absurd. In order to be adequate to such mighty productions, as far exceed all powers of comprehension, that cause must be Almighty. In order to be *ever*, and *every where* operating, that cause must be *ever* and *every where present*; and being intelligent, must, consequently, be omniscient, must know all subordinate causes and their effects throughout the universe.

The grand, beautiful, and beneficial works of creation, manifest not only perfection of power, but likewise consummate skill and wisdom, and benevolent intention; that wisdom and benevolence, must inhere in the Creator.

As this great First Cause possesses in himself perfection of every conceivable good quality and property, and as in Him are all the springs and sources of enjoyment, He must be perfectly blessed. As He Himself comprehends all existences, no extraneous cause can have influence over Him; He is, therefore, immutable.

From these reasonings, from these exalted views and considerations, Divine morality teaches the duties due from intelligent beings, towards their Creator, and the influence which the consideration of Him should possess over their actions.

Reverence for his adorable perfections; love for his benevolence; gratitude for the gift of existence, and of capacities and objects of enjoyment; constant sense of constant and absolute dependence upon Him; entire resignation to His will; perfect reliance upon His wisdom and goodness; uniform obedience to His commands; these are the sentiments which Divine morality inculcates with regard to God; these, ruling the mind and guiding the whole of the external conduct, all the outward signs and expressions of the thoughts and feelings. Hence, likewise, flow the duties of prayer, of private and public worship, offered to Him, who was, and who is, and who is to come.

All these views, principles, and duties of Divine morality, revealed religion abundantly confirms, clearly illustrates, and powerfully enforces, by the motives of future life, immortality, and happiness.

To this final consummation of good, should all science, all principles, all feelings, all actions tend.

QUESTIONS.

What is moral philosophy, or ethics? Into what branches may ethics be divided? What is the province of personal morality? Under what heads are the constituents of human felicity arranged? What is the business of social morality? What are the duties of children to parents? Of brothers and sisters? Of husbands and wives? Of parents to children? Of friendship? Of fellow citizens? Of patriotism? What is the great end and subject of Divine morality? What are the duties owing to God, deduced from his attributes as manifested by the light of reason.

THE END.

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